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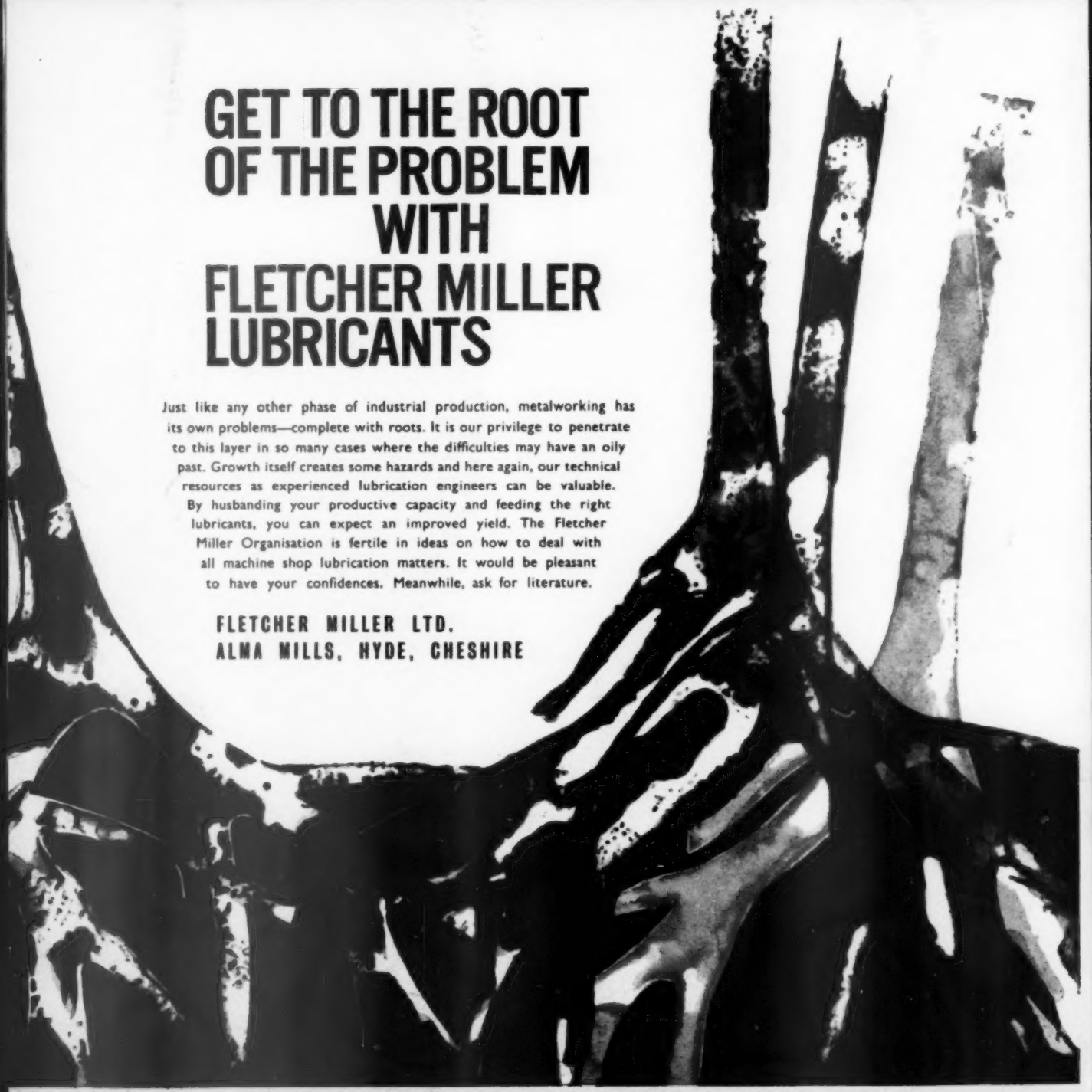

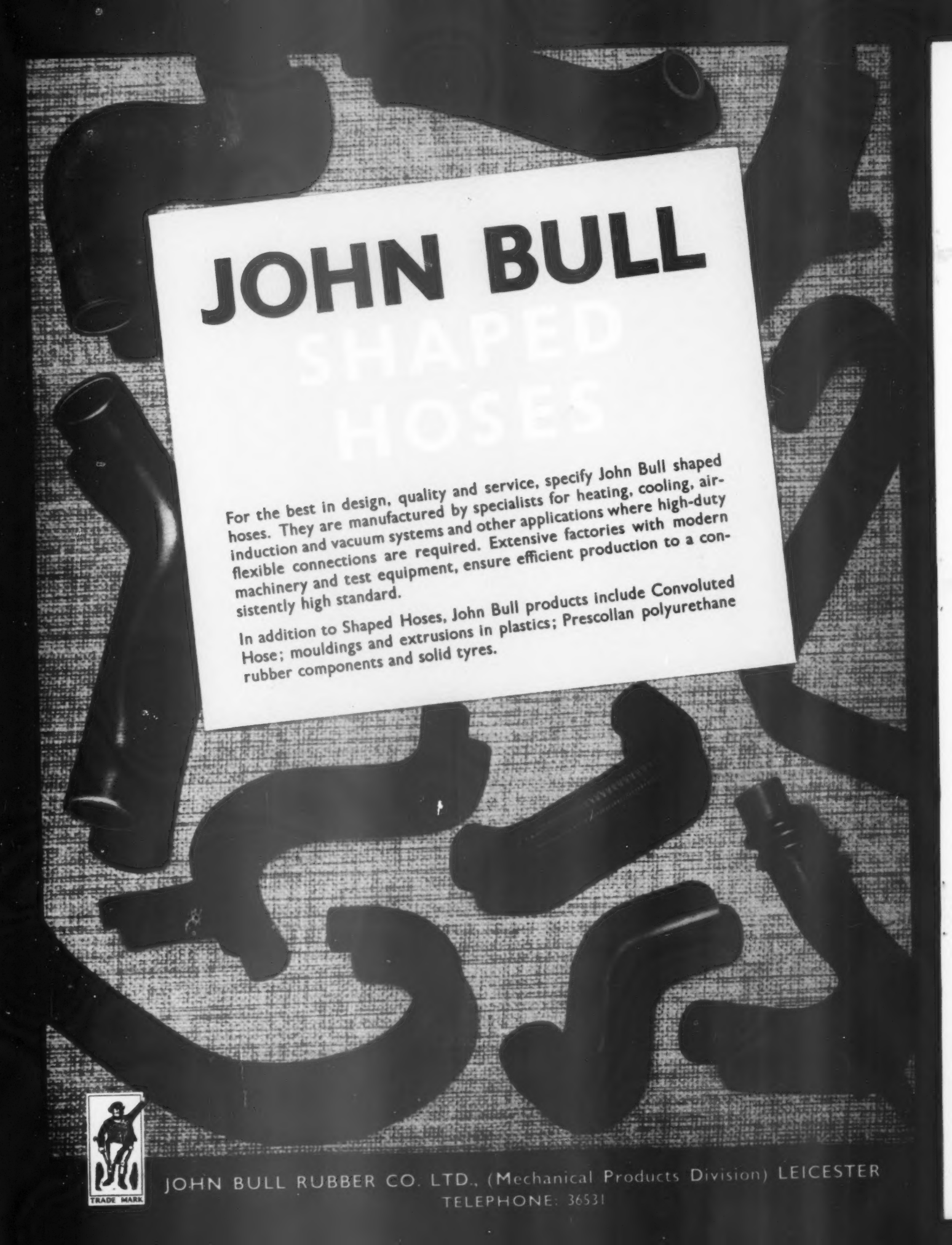
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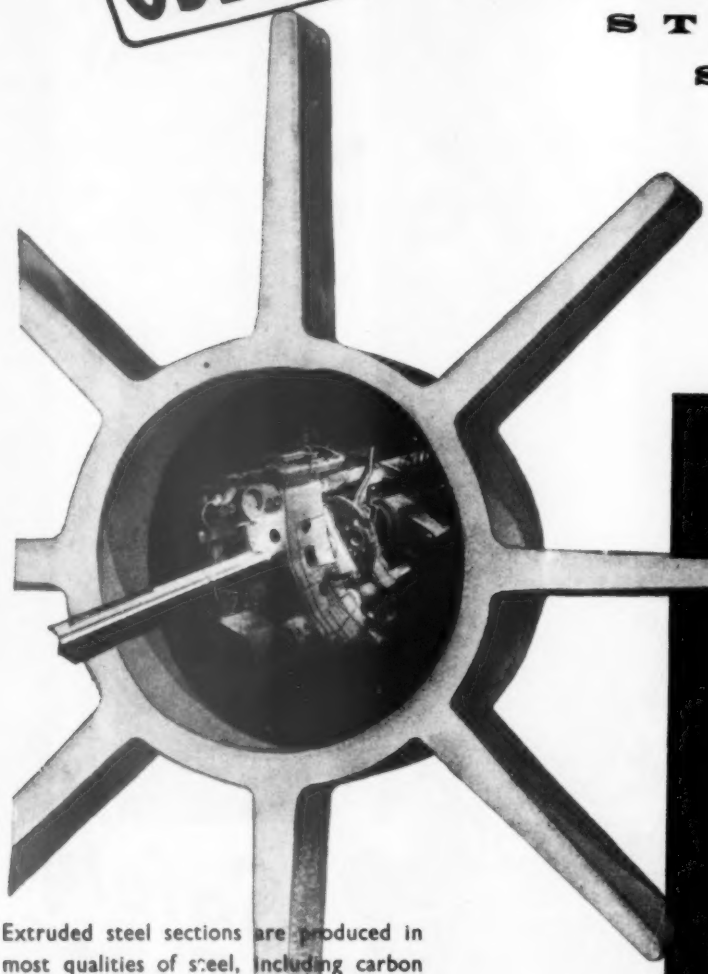

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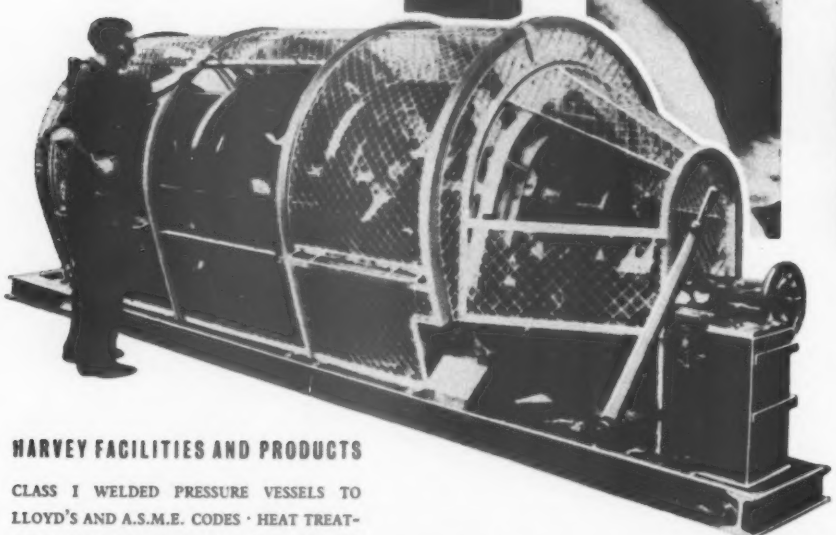

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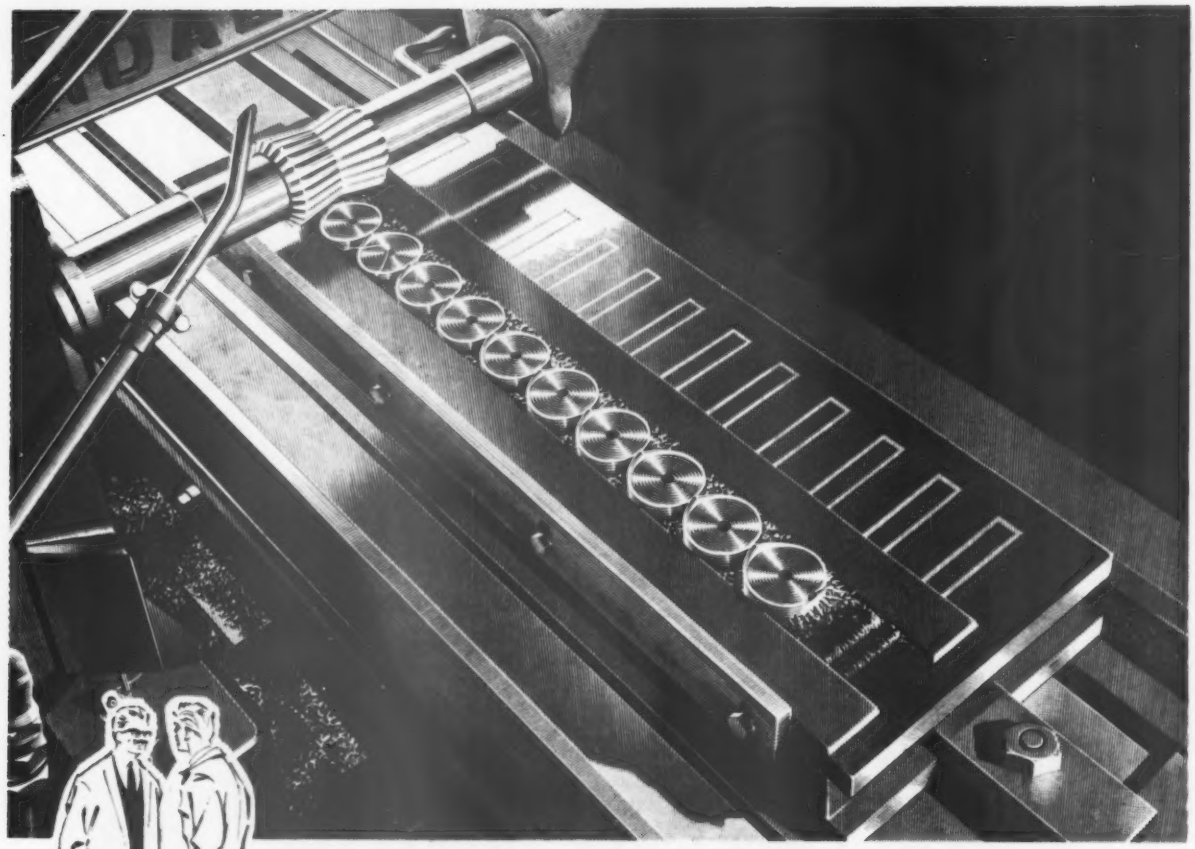

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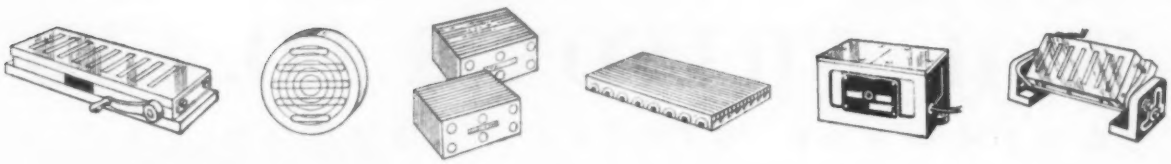

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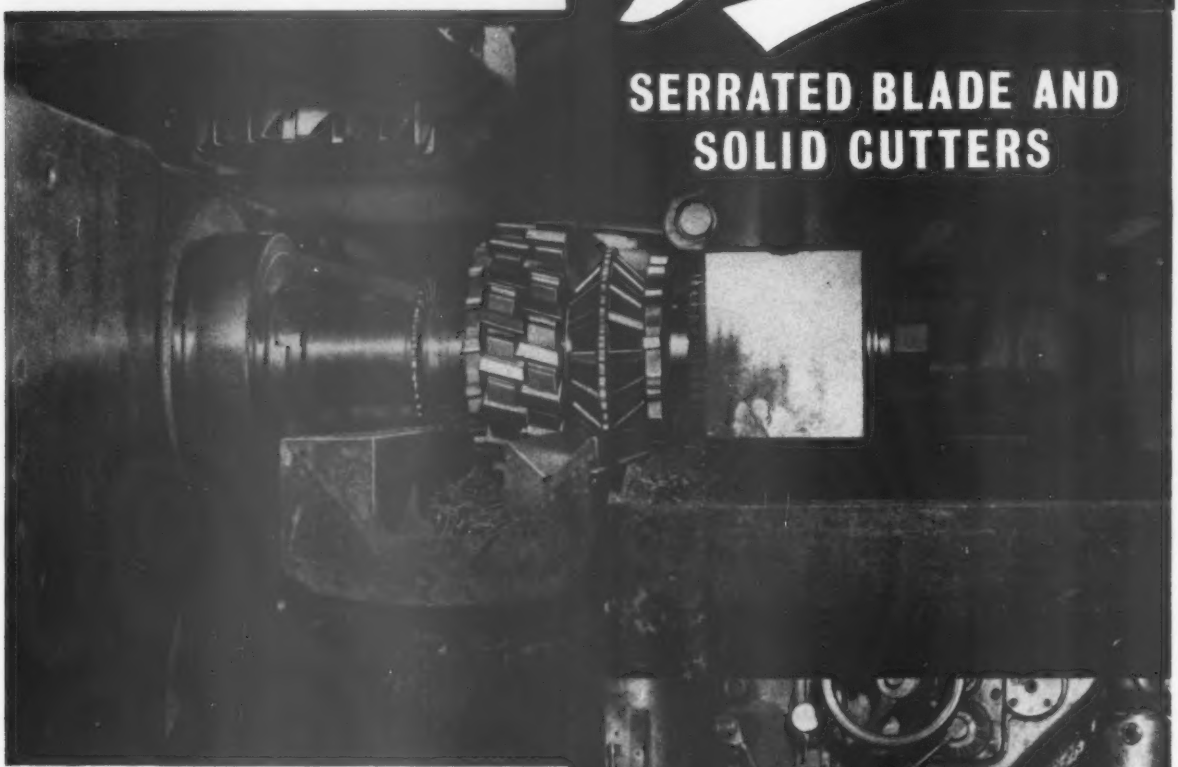

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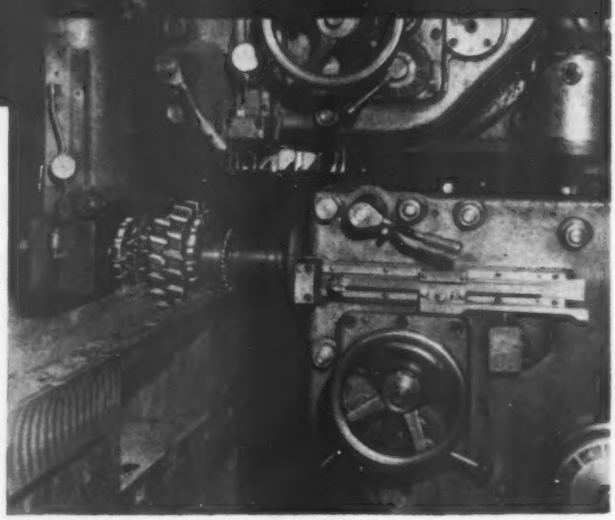

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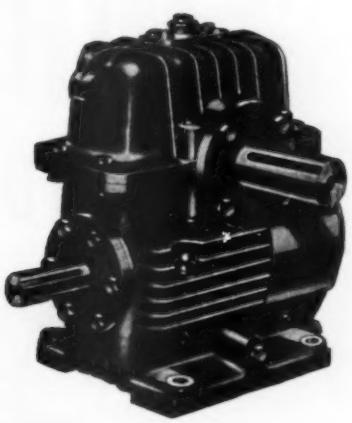

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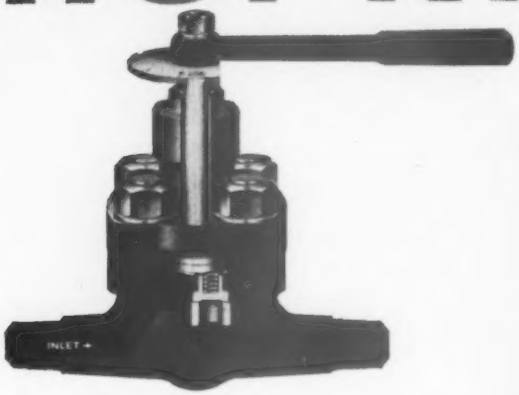

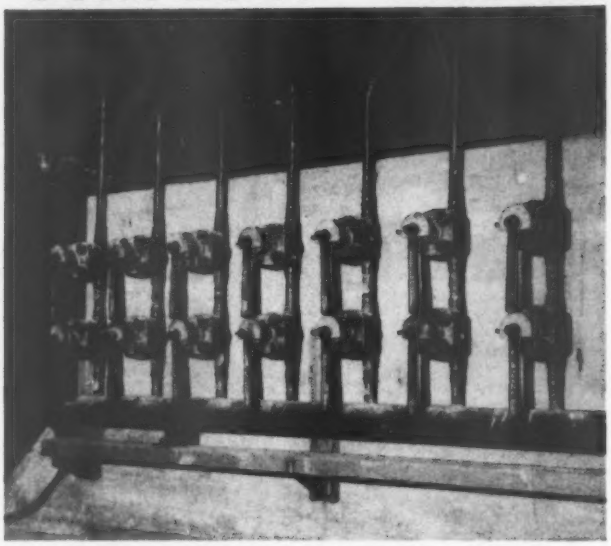

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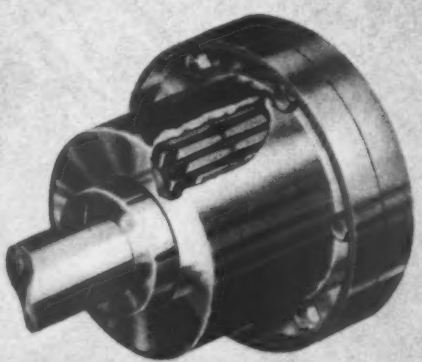

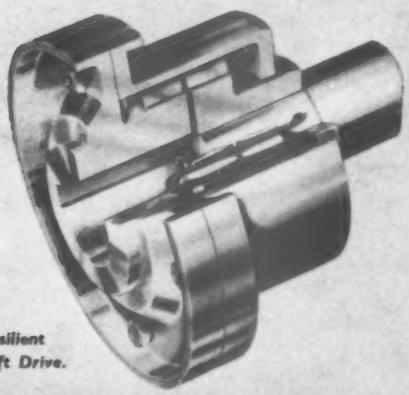

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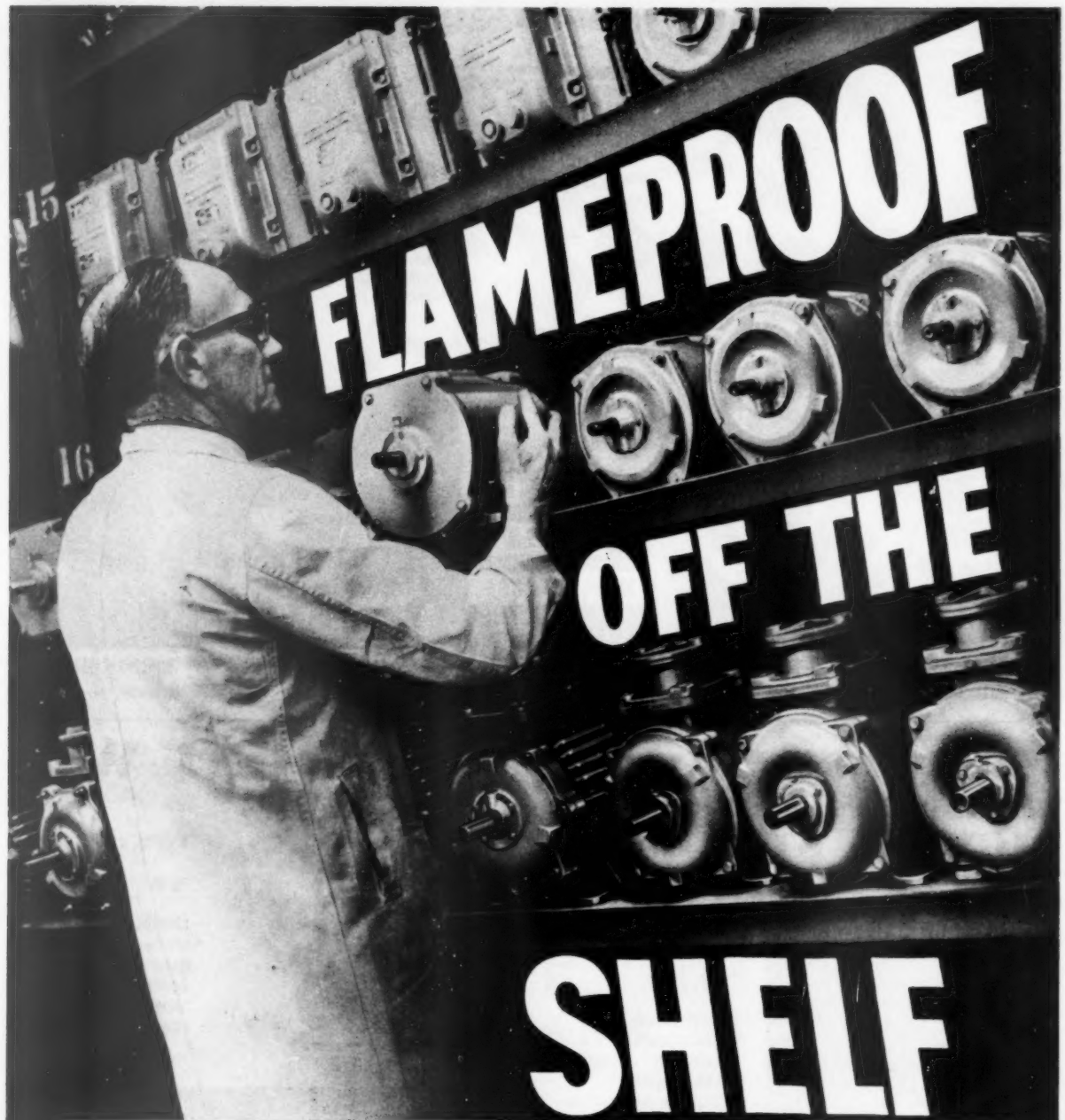

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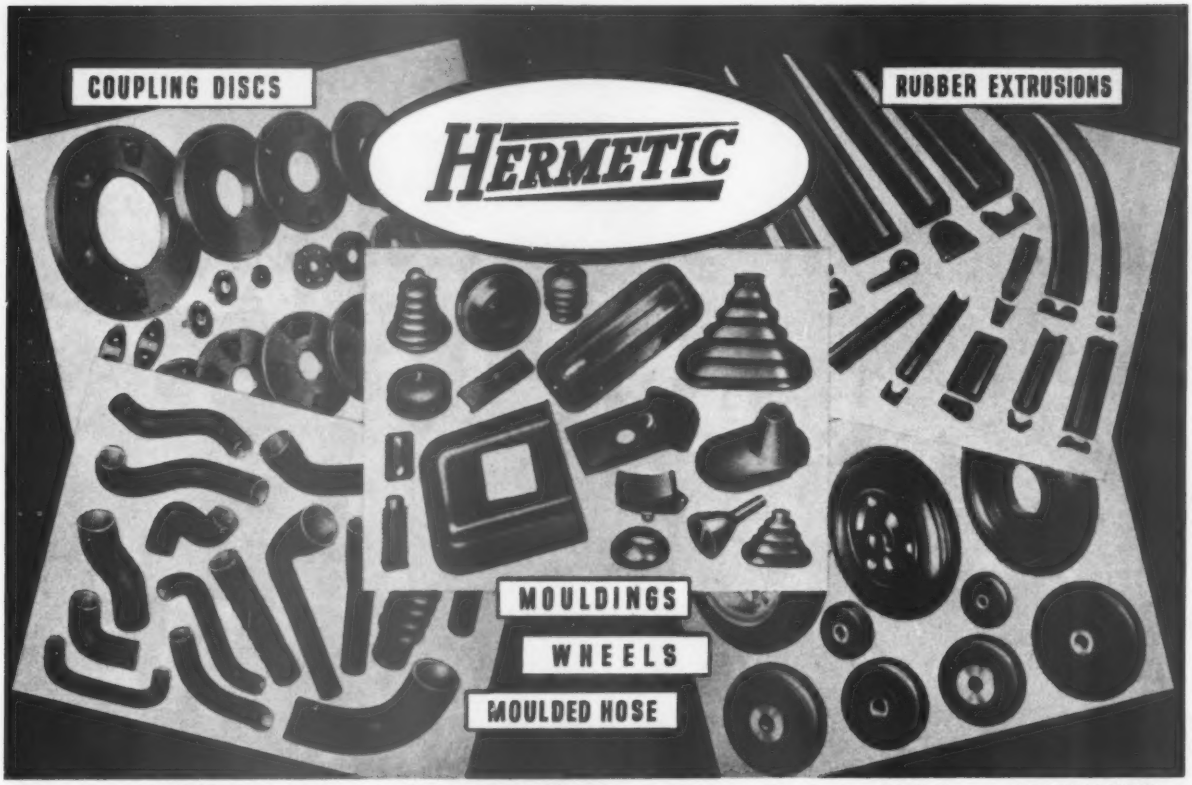

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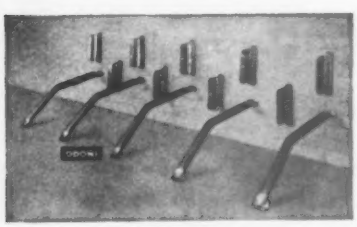

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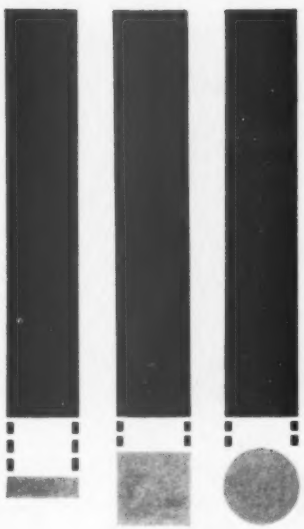

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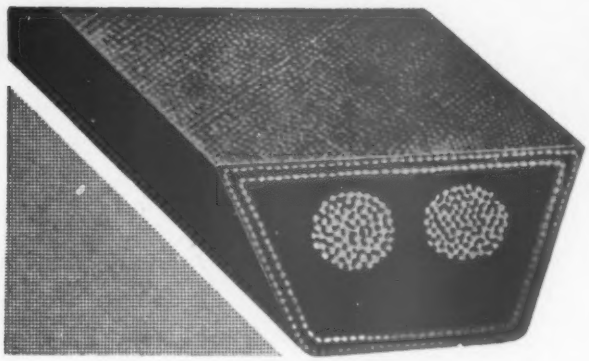

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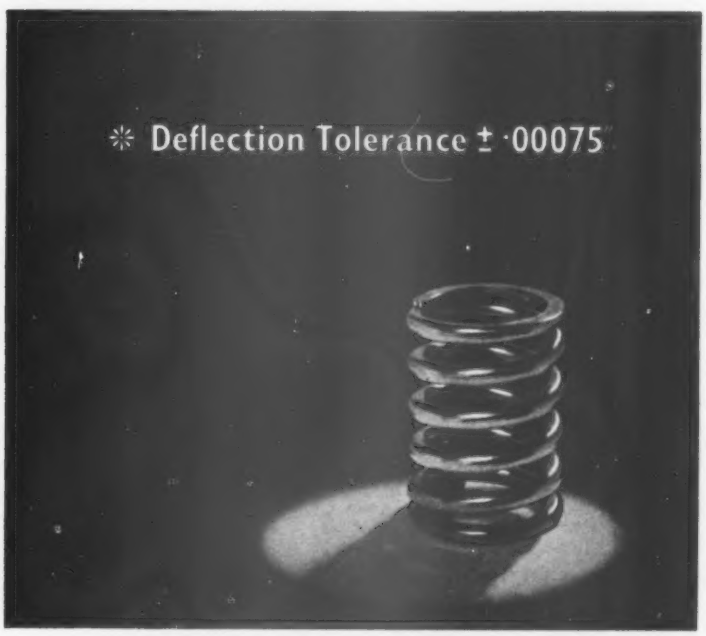

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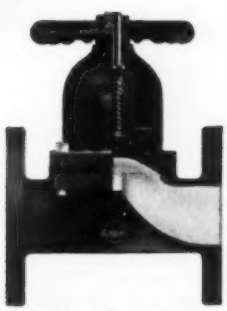

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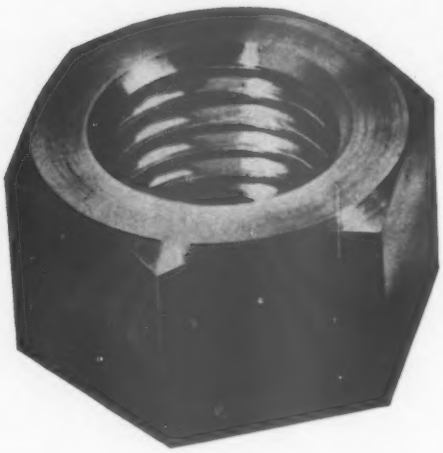

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Contents

Editorial: The Experiment is Dangerous 309

Log Sheet: Simulating Space Exploration. Switched Off After 61 Years. Large Gear Blanks. Cable Ship Bow Gear. Industrial Gas Turbines. Ship Research. Last Tram 310-311

Voltage Control.—D.C. Boosters and Balancers by J. L. Watts, A.M.I.E.E.
The uses of boosters to gain increased voltage and of rotary balancers for three wire systems... 312

Spheroidal Graphite Cast Iron and Its Applications by G. FitzGerald-Lee F.R.S.A. 313-315

Letters to the Editor: Trade Promotion with the Common Market. Dimensional Analysis..... 315

Fluid Flow Parameters and Solutions—II
A discussion of formulae in current use for dealing with turbulent flow conditions..... 316-318

Preliminary Design of Gas Turbine Plant—XI by W. R. Thomson, B.Sc.Tech
Blade section and modulus 319-320

Screw Thread Standards
An outline of the evolution of thread standards and a review of their present position..... 321-322

Nuclear Fuels for Power Stations
by J. R. Finniecome, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F., Consulting Engineer
Types and properties 322-325

Vinyl Film, Sheet and Coatings
Vinyl coatings range from films to thick coatings. 'Strippable' coatings are important for the temporary protection of tools, machine parts, etc., during transport or storage..... 326

Battery Power and Comparisons
Factors affecting battery performance and selection, and likely developments with fuel cells and application of water-activated silver-magnesium cells. Standard forms are evaluated on a cost/energy basis 237-329

Production Practice: by John Waller
Back Facing Tool. Self-contained Micro-adjusting Tool Head. Checking Bores of Small Batches. Quick Acting Clamp 330-331

Machine Tool Record: Spark Machining. Grinding Wheel Touch Indicator. Cold Billet Shear. Rotating Centres. "Throw-away" Tip Tool. Precision Protractor. Programme Drilling. Woodworking Tool Grinding Machine 332-333

Technique: High-pressure Optical Apparatus. Making Welded Drums for Large Boilers. Air Bearings 334-335

Business and Professional: Personal. Obituary. Addresses. Contracts and Work in Progress. Business Developments. Trade Literature. New Factories 339-342

Product Reviews: New 1½ Litre Ford Industrial Engine, **318.** Sealed Subminiature Switch, **320.** Wire and Cable Ducting, **320.** Air Filters, **320.** Operation Training Unit, **325.** Bright Copper Plating, **325.** Industrial Dryer, **329.** Nylon Universal Joint, **329.** Furnace Charging Equipment, **329.** Electro-magnetic Flowmeter, **329.** In Brief, **336.**

Books.....337-338 **New Standard**.....338

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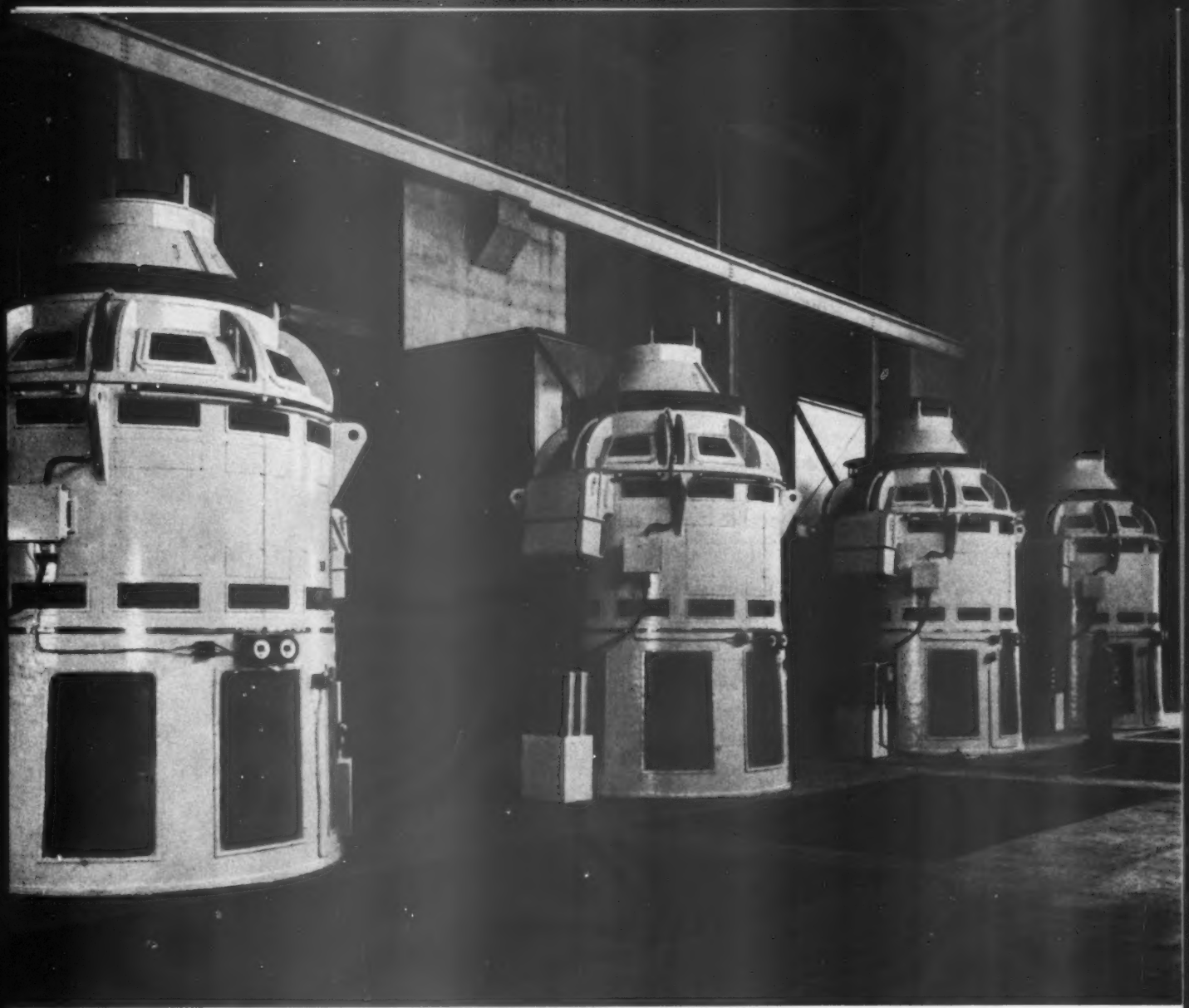

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The Experiment is Dangerous

THE intensive study that goes into rocketry possibly involves all the sciences and technologies, and amongst the gamut of human activities it is very likely unique in that respect. Perhaps the only other activity that comes anywhere near it in diversity is modern warfare, the urgent pressure of which brings in its train much new knowledge and experience in science and engineering and in psychology, surgery and medicine, to mention only the more noticeable subjects in which advances are made. Rocketry, especially under the pressure of international political rivalry, explores a similarly wide range of interests. The human being has never been so thoroughly observed in health as the passenger is in the rocket. New materials and fuels are developed, control mechanism attains a new pinnacle of accuracy, and navigation takes on new dimensions. Meteorology becomes more like its name.

Rocketry, like war, is an expensive business and the vast sums of money spent on it stir up great industrial activity and inject life into national economies. Like war it has no material end product. The result in both cases is knowledge with experience, some of it new, and some of it useful and of a kind which might never otherwise have been obtained. No one can explain with scientific absoluteness why wars occur. They are a human phenomenon and observably serve as a melting pot from which comes some precious metal. There is something of the same fever in international rocket rivalry, especially as it is accompanied by display in the form of competitively bigger explosions which the protagonists cannot use for any other purpose than to learn more about the science and technology involved. If the world is lucky enough in its politicians for long enough, perhaps the ultimate secret of nuclear energy locked up in the nuclear explosions will be discovered and the logical next step will absorb attention and the lethal danger will fall behind.

At the British Association meeting in Manchester Sir John Cockroft said that a year ago scientists thought they might have discovered all the members of the elementary particle family, and then a new variety of still more ephemeral particles was discovered. This was ever the pattern, and before long genius will perceive the nature of the illusion, the truth will be established, and off will go discovery on a new and broader path. The "how" goes on much faster than the "why": indeed the latter has never had any precise basis: the incredible speed of scientific discovery is of itself too much for the philosophers to explain. It is as if that domain were in a part of the mental spectrum which the brain has not as yet found an instrument for perceiving. Yet the whole scientific aura, as sensed by the intelligent non-scientific observer, is one of purpose even though the nature of the experiment is dangerous. Obviously, capability and integrity are all important throughout every phase of the endeavour.

LOG SHEET

Simulating Space Exploration

The flight path of the "Orbiting Geophysical Laboratory," to be launched from Cape Canaveral early next year has been reduced to a set of mathematical formulae now being processed by two IBM 7090 and six IBM 1401 data processing systems at Redondo Beach in California. The mathematical model is being used to determine how long the satellite will live and, by adding more equations to represent the environment of space, to simulate every action the satellite will take during its life.

By simulating months before a flight date, the computers are used to design wiring circuits, to study the reliability of the power supply, and determine every aspect of the satellite's purpose and performance.

During the average day some 350 individual jobs are handled by the computers, involving 25 million words of information, a volume which would take a typist three years to duplicate. Special data collection systems are used to record work as it moves through the various machines within the computing centre, necessary to avoid waste of time and capacity by determining time for each complex step and for the complete job.

The computer centre at Redondo Beach is working three full shifts a day to meet the demands for answers to the questions of the new technology of space exploration.

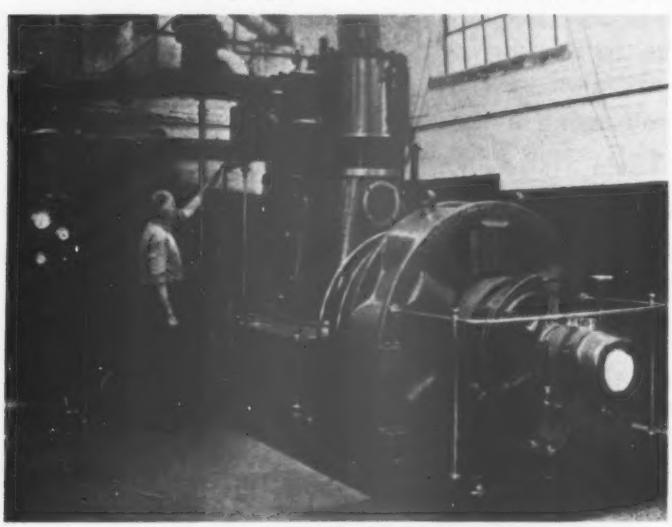
Switched Off after 61 Years

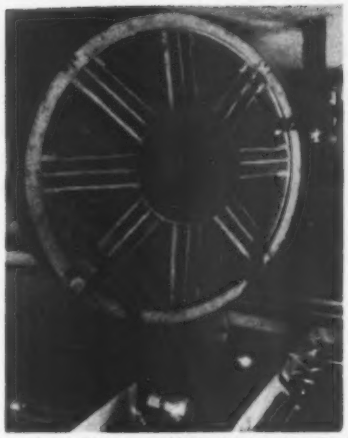
A 200 kW 500 volt Laurence, Scott d.c. generator driven by a 350 rpm Bellis and Morcom steam engine has recently ended its useful life after 61 years. Supplied originally to the King's Lynn Corporation Electricity Department, the set was sold, when the system was changed to alternating current, to J. T. Stanton & Co. Limited, timber importers and sawmillers of King's Lynn, and has been used to supply the power requirements of the mill, steam being raised from wood waste.

Now a better use has been found for the waste and the mill power is supplied from the mains.

The set has had a busy but uneventful life. At a modest estimate it has run at least five thousand million revolutions and has generated thirty million units or more. A few years ago the generator was flooded in the East Coast floods, but after being cleaned and dried out it went back to work without further attention. It is fitting that the new a.c. motors should have been supplied by Laurence, Scott & Electromotors Limited, but the engine makers must be content with pride in the fine performance of their product, which doubtless would have kept going for many more years if it had not literally run out of steam.

A Laurence, Scott generator driven by a Bellis and Morcom Engine which has just been retired after 61 years service. Used originally by the Kings Lynn Corporation Electricity Department the set has for many years been generating power for the works of J. T. Stanton & Company Limited, timber importers and sawmillers of King's Lynn





One of two 25-ton gear blanks fabricated at David Brown Industries using Cooper and Turner Diadem "Opal" electrodes

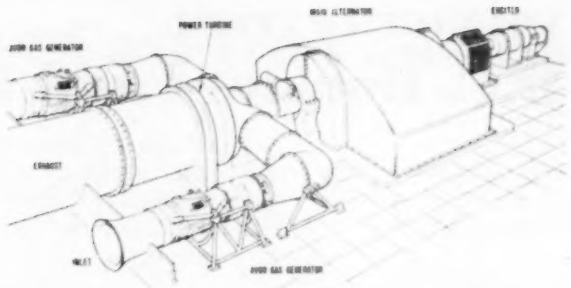
Large Gear Blanks

Fabrication has recently been completed at the St. Andrews Road works of David Brown Industries Limited, Huddersfield, of two large gear blanks which are probably the largest ever fabricated in single pieces. The blanks, each weighing 25 ton, have an overall diameter of 13½ ft and a width of 3 ft, and are being supplied to the order of Head Wrightson who are installing two 100-ton LD units and two 100-ton Kaldo units for the Consett Iron Company Limited, which, when completed, will be producing some 750 000 ton per annum of low carbon and special steel.

The fabrication has involved some of the heaviest flame cutting operations ever carried out in the works. The centre boss consists of a fully normalized, solid forging of En3 steel, weighing 12 ton and measuring 5 ft dia and 3 ft width. A 31 in. dia bore was cut in this boss with a British Oxygen 55 in. universal cutting machine fitted with a $\frac{1}{2}$ in. propane nozzle mixing head. Each boss was preheated and the cut was made in 40 min with less than $\frac{3}{16}$ in. taper over the full length. Slag was collected in a 4 ft deep concrete lined pit sunk in the floor below the cutter, a special skip being fitted to facilitate removal.

The spokes were of welded, box section construction, the steel being boiler quality plate to BS 14, cut on an electronically controlled Hancomatic machine. The welds were fully prepared to give a 1 in. throat thickness where they joined the arms to the boss. The rim of the

CABLE SHIP BOW GEAR.—This bow gear is part of a comprehensive contract for cable laying and cable handling gear being carried out by Submarine Cables Limited (a company owned jointly by A.E.I. and B.I.C.C.) for two new cableships now being built by Wartsila-Koncernen A/B, Finland, for the U.S.S.R. The bow gear comprises three steel sheaves, two Vee and one flat, of 7 ft dia on tread, 8 ft dia overall and 14 in. overall width



Installation of twin Rolls-Royce Avon gas generator in English Electric turbo-alternator set

gear was rolled from 7½ in. thick forged En14B steel slab on a Fielding & Platt 1000-ton hydraulic press, and had stiffening ribs welded to it to take the arms. The whole of this welding was carried out using Diadem Opal electrodes, a special low hydrogen electrode manufactured by Cooper & Turner Limited, Sheffield, and having the necessary weld metal impact properties for high standard welds of this nature.

Industrial Gas Turbines

Twin Rolls-Royce Avon gas generators are to power four emergency and peak load generating sets ordered from The English Electric Company Limited by the Central Electricity Generating Board for the new power station at West Burton. The gas generators are industrial versions of the Avon RA.29 turbojets which have been in world-wide airline service since 1958 and have completed two million hours operation powering Comet and Caravelle airliners. For the West Burton installation the exhaust gases from each pair of engines will be combined to energize an English Electric power turbine driving a 17·5 MW generator.

For this duty the Avons will run at a very modest rating, well below that used in civil airline operation. This is conducive to reliability and long life, and is in keeping with Rolls-Royce policy of not offering engines at military ratings for industrial duties. At the full civil rating a combined output of about 30 000 kW would be available.

The CEGB contract marks the initial order for industrial versions of Roll-Royce turbine aero engines, work on which has been under way for the past two years. The Avon has been offered by Rolls-Royce and English Electric for other duties ranging from base-load power generation to gas pumping in oil fields. For these applications the Avon is being developed to run on natural gas or diesel oil fuel. The ratings of these sets cover 8,000 to 50 000 kW.

Another gas turbine stand-by generating plant will be installed at the 2000 MW power station at Ferry Bridge. This new power station will have four 17½ MW stand-by sets each powered by a Bristol Siddeley Olympus gas turbine a development from the jet engine used in the Vulcan V Bomber. In the turbo-generator application the Olympus drives a free power turbine specially designed and manufactured by Bristol Siddeley to take full advantage of the exceptionally rapid build up of power. The free turbine in turn drives a Brush alternator.

Ship Research

The new circulating water channel for ship research now under construction at Feltham, Middlesex, will be one of the largest projects of its type in the world. The total cost will be about £500 000. The new testing equipment is the reverse of the usual towing tank: the water will be made to flow past a stationary model, thus enabling prolonged study of the flow conditions round critical areas of the hull of model vessels. The working section will be a steel channel 58 ft long with an open top, 12 ft wide and 13 ft 3 in. deep. Along the sides and bottom will be observation windows. A false floor is designed to give varying depth conditions. The models will be controlled from a movable instrument bridge above the top of the working section.

Prestressed concrete will be used in the construction of the water reservoirs, known as the "Upstream Stilling Section" and the "Downstream Stilling Section". The latter which includes the pump sump will be below ground water level and will be constructed within a sheet pile coffer dam. Water tightness will be ensured by quality controlled concrete. Both stilling sections will be roofed over with prestressed concrete beams.

The water will be circulated by a vertical axial flow pump and will be drawn from the sump and delivered to the upstream stilling section through a 10 ft dia steel return pipe outside the building. The English Electric Company Limited, are supplying the pump in conjunction with Sulzer Brothers and it is believed to be the largest of its type ever built in Britain. It will have a Kaplan type runner with oil servo-operated pitch changing mechanism and will discharge 960 cu ft per sec at 15 ft head. The drive will be from a 2300 hp 6-pole synchronous motor with a single stage helical reduction gear down to 140 rpm.

G. Percy Trentham Limited, Pangbourne, are erecting the building and Hall Engineering Limited, Shrewsbury, are making the working section.

Last Tram

Associated Electrical Industries Limited has been associated with the Glasgow electric tram system, which ceased operation on the night of September 1, thoughout its 64 years' service. The first electric tramcars in the city—on the experimental Mitchell Street to Springburn line, opened on July 1, 1898—had B.T.H. equipment, while the sixty tramcars providing the last service—the No. 9, which operates between Auchenshuggle and Dalmuir West—all have either B.T.H. or M-V equipment.

VOLTAGE CONTROL

D.C. Boosters and Balancers

In our February issue the author discussed the external factors which can affect the voltage of a d.c. generator and described methods of regulating field currents to obtain precise control. He now treats of the uses of boosters to gain an increased voltage and of rotary balancers for three-wire systems

By J. L. WATTS, A.M.I.E.E.

VOLTAGE is sometimes required which is above that of the available supply, whether this is derived from public supply mains or from a generator. This may be necessary fully to charge a battery having a nominal voltage similar to that of the supply. The extra voltage can be obtained by connecting the armature of a suitable low-voltage booster in series with the battery between the supply terminals as in Fig. 1. The booster field windings F are fed from the supply through the regulator R.

To commence charging, the booster motor is started with minimum field current in the booster so that its armature generates little voltage. The breaker C is then opened after closing B. Charging then commences as soon as the regulator R has been adjusted to raise the booster voltage sufficiently, and continues under the control of R.

A series-wound booster, driven by a constant-speed motor, may also be connected in series with a feeder to compensate for volt drop on the feeder. Such a booster is usually designed to operate with a fairly low magnetic flux density in its field system. Since the field windings are connected in series with the feeder the field flux and generated voltage will then be practically proportional to the load current in the feeder.

If the load connected between one outer and neutral of a three-wire d.c. system is greater than that connected between the other outer and neutral, the voltage of the heavily loaded side will fall and that of the lightly loaded side will rise. In order to keep the voltages as near normal value as possible under such conditions, a rotary balancer is often used.

As shown in Fig. 2 the balancer consists of two identical machines which are directly coupled together and connected between the respective outers and neutral. The field windings of one machine are usually connected across the armature of the other machine. Then if the voltage of, say, the positive side falls due to increased load the field F_2 will be reduced, whilst the field F_1 will be increased, due to the increased voltage on the negative side. The armature A_2 will increase its speed as a motor and take load from the lightly-loaded negative side to reduce the negative voltage. A_1 is then driven as a generator by A_2 and supplies current to the positive side to increase the voltage on this side. Under balanced load conditions both machines run idly as motors.

Static balancers can deal with out-of-balance current of about 25% but cannot raise the voltage on the heavily-loaded side as can a rotary balancer. However, they have no frictional losses and are comparatively simple. As shown in Fig. 3 this balancer is simply a centre-tapped choke coil with mid-point connected to the neutral, and the ends of the coil connected to two slip rings on the shaft of the generator, these rings being connected to opposite points on the armature.

The armature windings of the generator thus feed alternating current to magnetize the core of the choke coil. Any out-of-balance current is allowed to pass through the choke coil to the armature windings of the generator via the slip rings. Since the out-of-balance current is d.c. this creates little volt drop in the choke; the volt drop may be no more than about 1% for 25% out-of-balance current. Under balanced loading only a small magnetizing current passes through the balancer from the generator. For heavy out-of-balance currents two or more choking coils, with four or more slip rings, may be used to distribute the out-of-balance current in the armature windings of the generator, to avoid unequal heating of the armature.

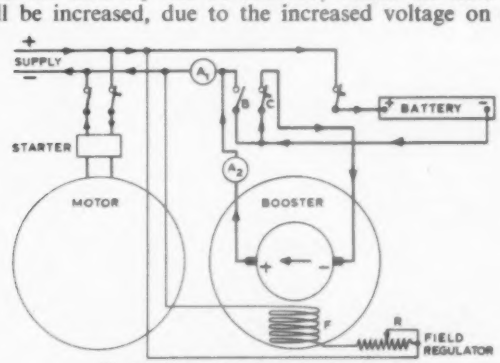


Fig. 1.—Connections of a battery booster set

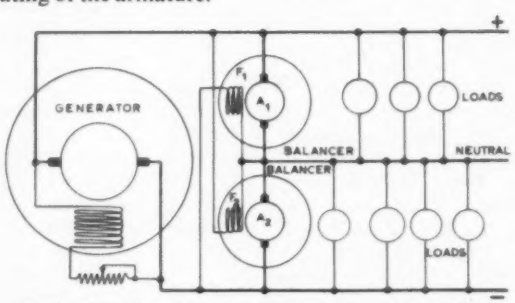


Fig. 2.—Connections of a rotary balancer on a three-wire d.c. circuit

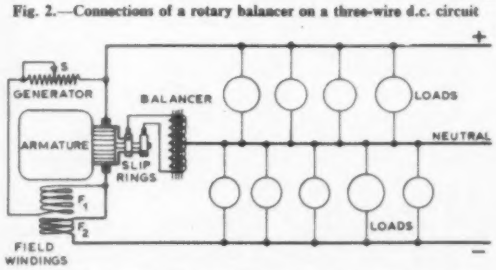


Fig. 3.—Connections of a static balancer on a three-wire d.c. circuit

Spheroidal Graphite Cast Iron and Its Applications

S.G. cast iron is a well developed material which has steadily grown in importance and application since it was first introduced. This article offers a detailed survey of the material, and its present day properties and uses

By G. FITZGERALD-LEE, F.R.S.A., M.I.E.I., A.R.Ae.S.

GREY cast iron contains carbon in the form of graphite flakes which create discontinuities and act as stress raisers, rendering the metal weak and brittle. The more compact, isolated form of graphite formed in malleable iron of light section by extended heat-treatment gives a higher mechanical strength and ductility. In ductile iron, in which spheroidal graphite is formed by the presence of a small amount of magnesium retained in the iron, discontinuities are eliminated with the result that the properties of the material are greatly improved, including its toughness, and there is no limit to the size of the casting.

Ductile iron is thus characterized by having high strength, toughness and ductility, together with excellent casting properties and good machinability; its modulus of elasticity is high and it is resistant to corrosion and abrasion. There are at present five types of ductile iron: pearlitic, hardened, ferritic, alloyed and austenitic. Its mechanical properties can be seen in Table I, compared with those of high-duty flake-graphite cast iron.

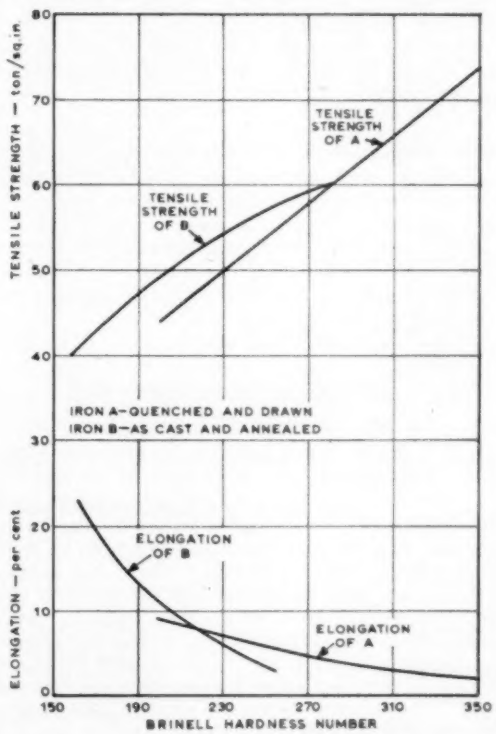
Pearlitic ductile iron is the normal condition of ordinary as cast sections up to 2 in., in which much of the carbon is in combined form and the structure consists of mixed ferrite and cementite with spheroids of graphite. The result is a hard, strong iron with twice the strength of grey cast iron. The properties can be improved by normalizing, which is effected by heating the castings to above the critical temperature, soaking at this heat, then cooling freely in air. Heat-treatment at 550° C is used to relieve the stresses in complex castings and parts in which maximum stability of dimensions is required.

Ductile iron can be hardened by quenching and tempering, the resulting properties, including quenching from 850° C and tempering at three different temperatures, are shown in Table II. Although ductile iron responds to flame or induction hardening, the best results and maximum hardness are obtained in the pearlitic or normalized grades. The addition of nickel promotes hardenability and 1% to 2% should be specified for all castings which are to be given a hardening heat-treatment.

When pearlitic ductile iron is annealed, the structure of the matrix becomes ferritic, the combined carbon is broken down and distributed as graphite spheroids in the matrix, resulting in an iron with maximum toughness and ductility and increased elongation. Nickel increases the tensile strength of annealed ductile iron without appreciably affecting its impact resistance or elongation. The addition of about 1% of nickel leads to a single metal which satisfies the higher tensile strengths, higher elongation and impact requirements of relevant specifications. Heavy section castings are partly annealed during the slow cooling which occurs after solidification and they usually have, as cast, a mixed structure of pearlite and ferrite.

By alloying appropriate proportions of nickel, molybdenum, chromium or other elements, special matrix structures can be developed to produce acicular, martensitic or austenitic castings, typical properties of which are also shown in Table II. Austenitic ductile irons, such as Ni-Resist are alloyed with up to 30% of nickel, giving high corrosion resistance and superior mechanical properties; other austenitic ductile irons, used for their magnetic properties as well as their strength, are of the nickel-manganese type.

Ductile iron—which is normally mainly pearlitic in matrix structure—has tensile strength ranging from 25 to 45 ton/in². for normal iron to 60 ton/in².—equal to high-tensile steel—for acicular irons containing nickel and molybdenum. Even higher tensile strengths can be obtained by normalizing or quenching and tempering. The stress/strain curve resembles steel more than cast iron, the strain being directly related to the stress up to a definite yield point. The proof stress taken from this



The relationship between tensile strength, elongation, and hardness of ductile iron

significant point is, unlike the 0·1% of other ferrous metals, usually taken as 0·2% of the gauge length deviation from the straight line of proportionality. The yield point is uniformly high and well above that of malleable iron—especially in the case of ferritic ductile iron with 2% of nickel. Such irons can thus sustain heavy loads without permanent deformation.

In both the ferritic and pearlitic types, the modulus of elasticity is 25 × 10^6 psi, and in the high-alloy austenitic irons it lies between 15 and 18·5 × 10^6 psi.

The mechanical properties of cast metals generally decrease in proportion to increase in section thickness; ductile iron follows this rule, but the rate of decrease of strength is considerably less than in flake-graphite irons. It is due to this and to its generally high mechanical properties that ductile iron has, in massive sections, three times the strength of flake-graphite iron in similar sections: sections of 40 in. have a tensile strength of about 20 ton/in.², compared with the 7 ton/in.² of flake-graphite iron of the same mass.

Ductile iron is also far more resistant to impact than is flake-graphite cast iron, in fact, annealed ferritic ductile iron has an impact value twelve times higher than high-quality flake-graphite cast iron; for impact-resisting castings the fully-annealed ferritic grade of ductile iron should be used; the annealed iron also has an elongation of from 12% to 25%. Although, as with other high-strength ferrous metals, the endurance ratio—the ratio of limiting fatigue strength to tensile strength—usually falls with increasing tensile strength, the fatigue strength itself of ductile iron is considerably higher than that of ordinary iron and even straight carbon steel. Further, as Table I shows, the effect of sharp notches, as indicated by the stress concentration factor, is decidedly less than with steel so that the working fatigue strength is good and makes the metal very suitable for such parts as crankshafts.

Ductile iron responds to all kinds of heat-treatment and it can be alloyed to form special matrix structures with their specific properties. In its softest state, full annealing causes carbon to leave the matrix for the spheroids, to form ductile ferrite with a Brinell hardness of 150. Soaking for a short time at austenising temperature causes the carbon to enter the matrix, resulting, after quenching, in a Brinell hardness of 700—much higher than white cast iron and twice the figure for mottled cast iron. Flame or induction hardening can produce similar hardness locally. Hardness figures between 150 and 700 Brinell can be obtained by various oil-quenching and tempering treatments. Normalizing results in good mechanical properties with a Brinell hardness of about 280. The relationship between hardness, elongation and tensile strength is shown in the accompanying graph.

Like most cast irons, ductile iron is highly resistant to abrasion, with the added ability to resist unequally distributed loads and those involving impact, a typical example being that of heavy-duty gear wheel where the metal withstands surface breakdown or tooth breakage caused by impact or fluctuation in load. If the lubrication fails and dry working results, the metal is resistant to pitting, galling and scuffing. The nickel-alloyed heat-treated grades are the best for gears. The damping capacity of any cast iron is increased by the presence of graphite, which gives ductile iron an advantage over steel when it comes to absorbing vibration.

With regard to properties at high temperatures, the structure of flake-graphite cast iron changes at such heat and it suffers gas penetration, with consequent internal oxidation, which results in growth. Because the graphite spheroids are isolated from one another and do not provide ways for the penetration of gases—as do graphite flake networks—ductile iron is more dimensionally stable at elevated temperatures and it thus resists growth much better than the ordinary iron; surface oxidation is also much less.

As can be seen from Table III, the creep strength of ductile iron renders it suitable for steam and other medium-temperature work; many of the more highly alloyed ductile irons have creep properties equal to some

Table I.—MECHANICAL PROPERTIES OF DUCTILE IRON, AS CAST AND ANNEALED, COMPARED WITH THOSE OF HIGH-DUTY FLAKE-GRAPHITE CAST IRON

Property	H-D F-G Cast Iron	Ductile Iron as cast	Ductile Iron annealed
Maximum stress ...	ton/in². 18–22	35–54	24–35
Yield point ...	,, —	25–35	17–25
Elongation ...	per cent nil	1–5	10–25
Transverse rupture stress ...	ton/in². 38–42	55–65	55–60
Comprehensive strength ...	,, 60–65	65–80	48–58
Comprehensive yield strength ...	—	32–40	24–32
Elastic modulus ...	× 10^6 lb/in². 18	25	25
Brinell hardness ...	210–240	230–280	140–180
Impact Izod 10 mm² notched ...	ft. lb. 1	4	12
Impact Charpy 10 mm², unnotched, 40 mm span ...	,, 2	8	70
Endurance limit, unnotched ...	ton/in². 8·5	13–18	11–13
,, ,, notched, 0·05 in. radius ...	,, 8	9·5	8·2
,, ratio, unnotched ...	0·4	0·46	0·45
Damping capacity ratio ...	4	2	1

Table II.—TYPICAL PROPERTIES OF HEAT-TREATED AND ALLOYED DUCTILE IRON

Type	Treatment	Tensile Strength ton/in².	0·5% Proof Stress ton/in².	Elongation %	B.H.F.	Impact Izod 10 mm² notched
Ductile iron with about 1% Ni., as cast		35–44·5	25·5–35	1–3	220–280	0·7–1·5
Stress relieved	2 hr at 550° C	38–47·5	25·5–35	3–5	220–270	2
Normalized	2 hr at 850° C air cool	44·5–57	32–44·5	3–7	240–300	5
	quenched from 850° C, tempered at 350° C.	57–66·5	47·5–60·5	1	450–525	0·7
Oil-quenched and tempered	quenched from 850° C, tempered at 500° C	60·5–70	51–60·5	1–3	350–450	3·5
	quenched as above, tempered at 600° C	47·5–57	38–47·5	3–5	250–325	5
Flame-hardened	Surface-hardened	—	—	—	600–750	—
Annealed	2–4 hr at 850–900° C, 6–12 hr at 700° C	25·5–30·5	17–22·25	12–25	140–180	7–15
Acicular ductile iron, 3% Ni. & 1% Mo.		47·5–63·5	38–51	3	280–350	6
Austenitic ductile iron, 22% Ni.		25·5–30·5	14–18	10–25	140–200	15

alloy steels. They are also highly resistant to thermal shock—a property not possessed by ordinary cast irons—as is shown by the following experiment: a 6 in. flanged gate valve, such as is used in petroleum refineries, made of ductile iron, was bolted rigidly to a steel pipe and heated in an oil fire; at 730° C when red hot, it was quickly quenched with a fire hose. On examination, the valve showed no signs of damage although tested at three times its rated pressure. The stresses to which it had been subjected were so severe that the steel fittings had been buckled and the steel bolts holding the valve to the pipe had been sheared off.

Although, as in the case of other metals, the shock-resistance of ductile iron is reduced at low temperatures, its initial shock-resistance and also its resistance to embrittlement at low temperatures are both considerably greater than for ordinary cast irons—it is, in fact, even better than wrought mild steel for resisting embrittlement. Low-temperature properties are, of course, largely dependent on composition. Ni-Resist cast iron (a product of the International Nickel Company (Mond) Limited) retains good ductility at very low temperatures: its impact value at room temperature is 28 ft lb, at −18° C this figure is 15, at −73° 6·5, and at −196° C it is still 4. Like flake-graphite cast iron, ductile iron is resistant to corrosive attack by aggressive atmospheres, sea-water, alkalis and some weak acids; in this respect it is five times better than steel, which fact, together with its mechanical properties, makes it very suitable for use in the chemical and petroleum industries and in marine atmospheres. Further benefit results from the use of low alloy ductile iron with about 1·5% of nickel, which is used for heating coils and cargo piping on tankers. The austenitic ductile irons can resist even more severe conditions.

Designing for ductile iron is both more difficult and easier than designing for other ferrous metals: more difficult in that ductile iron has so many useful characteristics which are not readily apparent; and easier because due to these very characteristics in combination with its more orthodox properties, it can be exactly suited to any given requirement. To begin with, ductile iron freezes at a much lower temperature than steel, thus it is more suitable for the pouring of thin castings; although grey cast iron has the same freezing temperature it has not the strength and ductility of ductile iron, and malleable iron, though it has good ductility, cannot be used for pouring castings in all ranges of thickness, size and weight. The combination of all these characteristics into good design results in economies in both costs and weight: expensive forgings and weldings can be replaced by castings; accurate castings can save machining costs, and the resistance to abrasion, shock and high temperatures permits the replacement of more expensive materials for the same purposes.

Table III.—PROPERTIES OF DUCTILE IRON AT HIGH TEMPERATURES

Properties	As Cast	Annealed
	ton/in².	
Creep strength (1% in 10 000 hr) at 427° C	5–11	7–12
Stress Rupture		
100 hr at 427° C	18·0–24·0	13·5–15·5
1 000 ,, ,, ,, ,,	13·5–18·0	11·0–12·0
100 ,, ,, 650° C	1·7–2·1	1·5
1 000 ,, ,, ,, ,,	1·1–1·3	0·9–1·0
Melting Range, deg C	1120–1180	
Thermal Expansion, × 10⁶		
20°–100° C	11·5	
–200° ,,	12·2	
–300° ,,	12·6	
–400° ,,	13·1	
–500° ,,	13·3	
–600° ,,	13·5	

Ductile iron has about the same melting point as grey cast iron, together with better fluidity; having in the molten state all the good casting characteristics of grey cast iron, it has in the solid state the mechanical properties of steel; thus it can be used for intricate castings of light section which have to withstand high stresses and rough usage. With regard to size or weight, castings have already been produced ranging from one ounce up to 50 ton, and all ordinary foundry production methods are applicable to this metal. Designers should take full advantage of the chance to reduce section thickness which is made possible by the mechanical properties and castability of the material. Especially when ductile iron castings replace forgings or stampings, complete change in design may be both possible and desirable; hollow designs for example, which eliminate unnecessary metal and thus reduce weight and increase efficiency, can replace solid shapes. *To be continued.*

Trade Promotion with the Common Market

TO THE EDITOR OF MECHANICAL WORLD

Sir,—Some British firms are taking meaningful steps to ensure that they can not only survive but profit from our possible entry into the Common Market. For instance, we sold a new type of machine to a customer in Lisbon. The machine uses a well known English time switch. As soon as the time switch export manager here in England heard of this he said he would send his Portuguese agent to our customer right away to give personal instruction and advice on use and adjustment of the time switch. The time switch cost only £10. This, surely, is the attitude that will keep British industry prosperous in the hazardous days to come.

But there are other British firms who seem never to have heard the word "export"—"We are obtaining a translation from our translation service and will let you know what the cost of the translation will be. . . "!

From such disparate day-to-day attitudes towards exports one can see the pattern of the future for British industry—there are firms who will sail to success in the good ship "Common Market" and those whose float switches will sink without trace as they cross the Channel.

Yours faithfully

for The Thomas Hill Engineering Co. (Hull) Limited.

T. P. Hill.

(*Managing Director*)

Dimensional Analysis

TO THE EDITOR OF MECHANICAL WORLD

Sir.—I am writing with reference to the article "Dimensional Analysis" published in the August 1962 issue (No. 3517) of your magazine.

The method of checking the calculations by dimensional analysis is one of the simplist and most efficient and it is in common use with engineers on the Continent. It certainly deserves to be introduced also into British engineering practice.

However, there is a basic error in the article. The "dimensionless factor's unit" (if it could be called so) is: 1 (one) and not: 0 (zero) as it was shown at the end of the article.

W. P. Krzyzanowski,

Altrincham, Cheshire. M.Sc.(Eng).

Fluid Flow Parameters and Solutions—II

A discussion of formulae in current use for dealing with turbulent flow conditions

WITH turbulent flow the pressure loss in terms of a suitable friction factor can be written

$$\Delta P/\rho L = f_{turb.}\, V^2/2gD$$

In this case, however, there is no simple solution for determining the friction factor (f_{turb}).

In addition to being generated by a high flow R.N., the degree of turbulence, and hence the resulting losses, will also be dependent on the roughness of the pipe walls, leading to a multiplicity of solutions derived from various sources. It was also found from analysis of experimental data that the friction factor was also dependent on velocity and pipe diameter and that no single solution was likely to hold good over a wide range of conditions.

Later investigations have established that there are, in fact, three degrees of turbulence—so-called *smooth turbulence* where the pipe walls are smooth enough to have no appreciable effect (and are therefore eliminated as a parameter); *rough turbulence* consistent with high Reynolds Numbers where the friction factor varies with pipe roughness but is substantially independent of Reynolds Number (i.e. constant for a given value of roughness); and a *transition region* in which the friction factor varies between 'smooth' and 'rough' values, dependent both on roughness and Reynolds Number. This transition region refers specifically to *turbulent flow* and is distinct from the transition between laminar and turbulent flow, which is an entirely different form of transition occurring at a lower Reynolds Number. It is unfortunate that the same term is used to describe two different conditions, but it is standard practice and no harm is done provided the term 'transition' is always read or described in proper context.

The simplest solution is offered in the case of smooth bore pipes and tubes of relatively small diameter where the Reynolds Number does not exceed about 10,000. Here Blasius's solution for the friction factor in the Darcy-Weisbach formula applies and gives results consistent with practice.

$$\text{This gives } f_{turb} = 0{\cdot}3164\ \text{R.N.}^{-0{\cdot}25}$$
$$\text{whence } \Delta P/\rho L = 0{\cdot}1582\ \nu^{0{\cdot}25} V^{1{\cdot}75}/gD^{1{\cdot}75}$$

This can be rendered in engineering units as

$$\Delta P/\bar{\rho} L = \frac{Q^{1{\cdot}75}\nu^{0{\cdot}25}}{18750\ D^{4{\cdot}75}}$$

where P is in psi
Q is in cu in./sec
ν is in centipoises
D is in inches
L is in feet
and $\bar{\rho}$ designates the specific gravity of the fluid.

This formula is widely used for engineering hydraulic calculations in smooth bore pipes and tubes for all turbulent flow solutions (i.e. Reynolds Number above 2500) up to Reynolds Number = 10,000 although sometimes used up to R.N. = 100,000. It is tedious to manipulate as a formula for individual calculations and so is usually expressed in the form of nomograms or a series of charts giving pressure drop per foot run of pipe or tube against flow rate for a standard range of pipe sizes, each chart calculated for a specific fluid (i.e. a given specific gravity) at a specific temperature (corresponding to a specific viscosity).* Other charts may be calculated on a similar basis for, say, specific viscosities for unit specific gravity, permitting correction for other fluids by factoring.

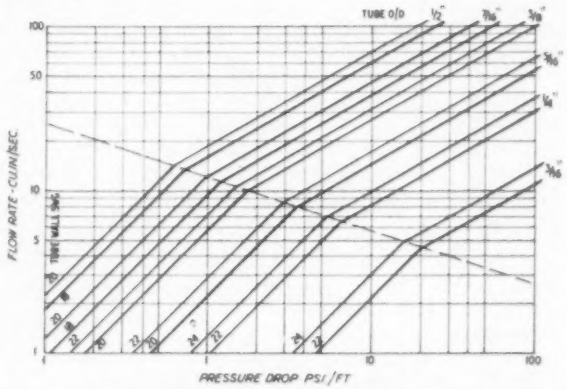


Fig. 3.—Pressure drop plotted against flow rate for DTD 585 hydraulic fluid at 20° C for a range of tube sizes

More exact solutions over a wide range of Reynolds Number can be derived from the Prandtl-Karman analysis of turbulent flow when the friction factor for smooth walled tubes with turbulent flow (smooth turbulence) can be expressed accurately as

$$1/\sqrt{f} = 2 \log \text{R.N.} \sqrt{f} - 0{\cdot}8$$

This is generally accepted as defining the *smooth turbulence* condition for flow Reynolds Numbers 50,000–3,000,000 or beyond, and is in excellent agreement with practical results. It will be seen that with smooth turbulence the friction factor is solely a function of the Reynolds Number of flow. The consistency of the formula is dependent on the condition that with smooth walls a film of laminar flow will be maintained in contact with the walls, i.e. at the boundary leading to one constant term (i.e. the 0·8 value which actually represents a minor empirical modification of the theoretical value derived from first principles). The other term then represents the losses attendant on the velocity distribution through the bulk of the flow.

Where pipe roughness is involved as a parameter—e.g. most larger sizes of pipes fabricated for fluid transport, traditional methods of analysis have employed one or other of the various sets of equations evolved by such authorities as Chezy, Bazin, Kutter, Manning, Barnes,

* Fig. 3 is computed for DTD 585 hydraulic fluid, specific gravity 0·886 at 20° C (equivalent to a fluid viscosity of 23 centistokes).

Hazen-Williams, Blair, etc.—largely based on deriving empirical solutions for the Chezy coefficient in the original Chezy formula for the flow in open channels—

$$V = C\sqrt{RS}$$

where C = Chezy coefficient
R = hydraulic radius or hydraulic mean depth
S = hydraulic gradient.

In general, the bulk of such work resulted in a series of equations of exponential form of the type

$$V = \text{a constant} \times R^x S^y$$

A limitation throughout has been the dimensional nature of the so-called constant or coefficient involved (whereas the friction factor in the Darcy-Weisback equation is dimensionless). Essentially the appropriate coefficient is derived empirically—i.e. to conform with the experimental data analysed—and hence such equations are strictly limited, in accuracy and use, to ranges covered by the original data. Outside this range they may be valueless, although they are still commonly quoted in engineering handbooks, etc., with a note of reservation—e.g. a table calculated on Kutter's equation with the note "this formula gives too low results for small pipes".

Nevertheless, formulae of the exponential type continue to be widely used—Manning's formula for example—and especially for piping systems handling cold and reasonably clean water. A general formula of this type is

$$Q = K\,D^x\,I^y$$

where K, x and y are constants, depending on the particular class of pipe; D is the pipe diameter in inches, Q the flow rate in gallons per minute and I the virtual

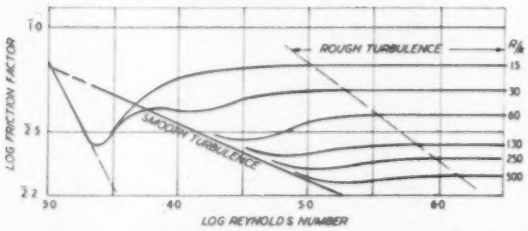


Fig. 4.—Nikuradse curves for pipes artificially roughened showing smooth turbulence limit, fully rough turbulent flow and transition region

slope of head loss divided by pipe length. Typical modern values of the constants used are

	K	x	y
Smooth non-ferrous pipes	35·8	2·71	0·57
Uncoated steel or wrought iron	31·3	2·69	0·55
Asbestos cement, bitumen lined	31·3	2·68	0·55
Bitumen coated steel, concrete, cement lined	28·6	2·68	0·54
Galvanized cast iron, plain or coated	24·2	2·67	0·52

Most useful work on the analysis of rough turbulence was done by Nikuradse employing pipes artificially roughened with grains of sand of uniform size (as well as on smooth bore pipes), using a 'roughness parameter' expressed as the size of the sand grains relative to the pipe bore. These data, plotted in graphical form in Fig. 4 show the characteristic flattening of the individual friction factor curves at higher Reynolds Numbers and the definite transition region between smooth walled turbulence and the 'fully rough' conditions. The greater the degree of roughness, quite logically, the greater the disruption of the laminar boundary film, which effect is also enhanced by increasing Reynolds Number so that at high Reynolds Numbers the friction factor becomes independent of R.N. (laminar boundary layer completely disrupted).

Under fully rough turbulent conditions the Prandtl-Karman analysis can again be applied, in this case rendering the equation in the form $I/\sqrt{f} = B + 2\log R/K$

where R = pipe radius
K = effective or equivalent diameter (depth) of surface roughness.

The quantity B determined consistently with the Nikuradse experiments is equal to 1·74, hence

$$I/\sqrt{f} = 1{\cdot}74 + 2\log R/K$$

which is generally known as the rough (turbulent) law, or the quadratic resistance law for fully turbulent flow and is independent of Reynolds Number. However, this applies to fully rough turbulence, associated with high flow Reynolds Numbers, and not to the transition region where the friction factor varies with Reynolds Number.

The gap between smooth turbulence and rough turbulence determinable from the smooth law and rough law respectively) can be filled by plotting experimental data—or, as has been done on several occasions, by 'guesstimated' extrapolation of the rough curves. These lead to a family of curves tied to a specific range of

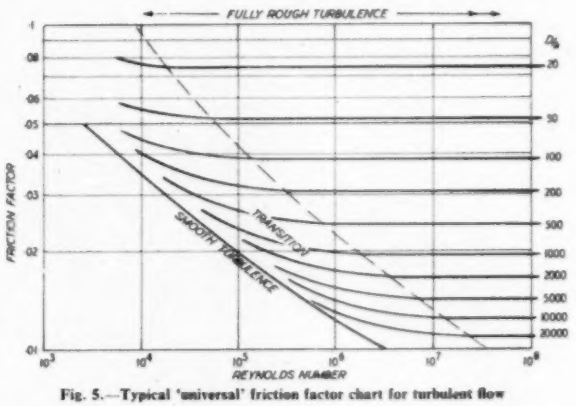


Fig. 5.—Typical 'universal' friction factor chart for turbulent flow

tests (and possibly test conditions) or estimates. Colebrook and White, however, have provided a mathematical solution for the transition range in the form of equation.

$$I/\sqrt{f} = -2\log\left(\frac{k}{3{\cdot}7D} + \frac{2{\cdot}51}{\text{R.N.}\sqrt{f}}\right)$$

using a similar parameter k for surface roughness (or, rather, the ratio D/k). This a complete family of curves can be plotted using the smooth law, the transition law (as given by the Colebrook-White equation) and the rough law, as in Fig. 5.

This is often referred to as a universal friction diagram, with friction factor, Reynolds Number and roughness ratio D/k as variables. These are not, however, basic engineering terms and for convenience of design application the universal friction diagram can be rendered in the form of special diagrams* reading in terms of flow velocity or flow rate, pipe diameter and hydraulic gradient, for given values of roughness k. Alternatively, for non-circular pipes and ducts, the diagram can be modified to read in terms of hydraulic radius rather than pipe diameter. The data available can then be applied directly

to specific engineering problems and corrected as necessary (e.g. viscosity correction may be desirable when computing flow velocity under rough turbulent flow where the product of velocity and roughness, Vk, is less than 0·01).

Application of a given universal friction chart, or a derived design chart, is dependent on correct evaluation of the surface roughness concerned in the specific problem, or its evaluation as designated on the chart. Besides adopting different ratios, e.g. D/k, $D/2k$ or R/k, k/d, $2k/D$, the actual recommendation of the value of k to be adopted for specific surfaces may vary between different authorities. It is necessary, therefore, to check that both the value of k used is consistent with the derivation or source of the diagram to be used, and the correct ratio is employed as the parameter. An advantage of all such charts employing k or 'equivalent sand roughness' as a parameter, however, is that they are far more sensitive to changes in surface roughness, and therefore far less critical in evaluation than the exponential forms of turbulent flow equations employing a nominal roughness factor. The Manning roughness value, for example, is proportional to $k^{1/6}$ and thus far more affected by changes in linear value of surface roughness.

Surface roughness, too, is not necessarily a constant factor, a surface deteriorating and becoming rougher with increasing age or service. A general formula to determine the appropriate value of k with increasing age is

$$k = k_o + \Delta T$$

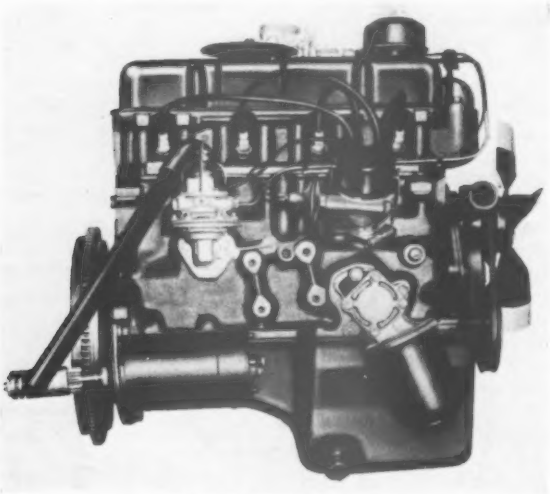
where Δ is a growth coefficient determined by practical tests or measurement of old pipes under similar working conditions and T the time involved. One such evaluation of Δ is

$$\Delta = (3{\cdot}8 - pH)/0{\cdot}1589$$

for asphalted cast iron pipes carrying water.

More work still remains to be done on the subject of evaluating surface roughness as a complete parameter, even to the extent of specifying different classes of roughness, but within the practical variations of the variables normally involved the modern methods of analysing turbulent flow loss on the basis of the smooth, transitional and rough formulas gives generally consistent results in agreement with practice.

* Wallingford, Hydraulic Design Charts, published by H. M. Stationery office.



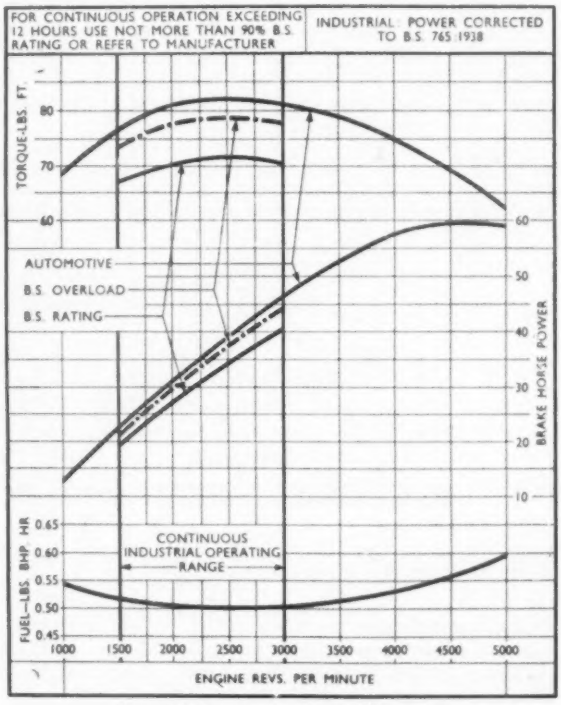
New Ford 1½ litre industrial engine

New 1½ Litre Ford Industrial Engine

An entirely new petrol engine of 1½ litre capacity which develops 59.5 bhp at 4600 rpm is the latest Ford industrial engine to emerge from Dagenham. It is the 122E Series and follows a similar design pattern to its smaller brethren, the 105E (997 cc) and 112E (1340 cc) petrol engines, the 122E replacing the latter in the new Consul Classic car. Designed to fill the gap between the 112E and the larger 216E (1703 cc), the new 122E power unit will be also of special interest to the automotive and marine industries who have already made extensive use of the smaller Ford power units in special sports cars, racing cars, motor boats and cruisers.

Technical specification of the 122E is as follows:

Bore	3.19 in.—81 mm
Stroke	2.86 in.—73 mm
Swept volume	91.5 cu in.—1498 cc
Comp.ratio	8.3 : 1



Characteristic curves of new Ford 1½ litre engine

Max. bhp	
Automotive, net	59.5 @ 4600 rpm
B.S. overload	44.5 @ 3000 rpm
B.S. rating	40 @ 3000 rpm
Max torgue.	
Automotive, net	81.5 lb/ft @ 2300 rpm
Weight	244 lb—110.7 kg
Height	23.6 in.—59.9 cm
Width	17.55 in.—44.6 cm
Length	22.01 in.—55.9 cm

With this addition to the comprehensive Ford range, the Ford Industrial Division now market nine petrol and four diesel engines ranging from 10 to 100 bhp.

Preliminary Design of Gas Turbine Plant—IX

Blade section and modulus

By W. R. THOMSON, B.Sc.Tech.

9.23. Combined stresses

The total steady stress is the sum of the centrifugal and gas bending stresses, f_c and f_b respectively. In the absence of other knowledge of the fatigue stresses due to vibration, the blades are designed so that an additional alternating stress, f_f, equal in magnitude to n times the bending stress, f_b, will just cause rupture in the required life when coupled with the steady stress, $f_c + f_b$. A parabola is assumed for the Gerber diagram i.e., the plot of f_f against f_s each reaching its own limit F_f and F_s respectively when the other is zero. See Fig. 22. The

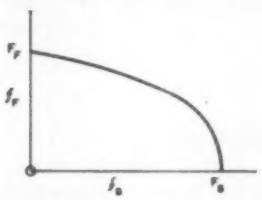


Fig. 22. Gerber diagram for high temperature alloys

equation of this curve is $F_s - f_s = (F_s/F_f^2)f_f^2$. But $f_f = nf_b$, and $f_s = f_c + f_b$, hence substituting in the curve equation gives the safe bending stress available for design as

$$f_b = \frac{1}{2F_s}\left(\frac{F_f}{n}\right)^2\left\{\sqrt{1 + \frac{4F_s(F_s - f_c)}{(F_f/n)^2}} - 1\right\}$$

n would lie between 3 and 6 the latter value being applicable to industrial long-life plants.

9.24. Blade section

The blade could now be drawn out and the following method may be used (see Fig. 23). Two horizontal lines *aa* and *bb* are drawn the blade width w apart. This value is of course unknown as yet and any size may be used, say 5 or 10 in., as it is only *shape* that is of importance. A third line *cc* is drawn horizontally midway between them. From a point *d* on *aa* the blade inlet angle β_1 is set off from the vertical to give *e* on *cc*. From *e* a line *ef* is drawn making the blade outlet angle β_2 with the vertical through *f* on *bb*. Then *df* is joined and represents the first approximation to the chord line. The angle *df* makes with the vertical through *d* is the stagger ζ ($\tan\zeta = \frac{1}{2}(\tan\beta_2 - \tan\beta_1)$). With *e* as centre a circle is drawn with radius equal to the blade thickness t_c using the known $(t/c)_c$ for the blade from the table of 9.17 and measuring c from *df*. Along *bb* mark *fg* equal to $s - 0{\cdot}02w/\cos\beta_2$ using the known (s/c) from the same table. Draw a semicircle on *fg* as diameter to intersect *df* in *h*. Draw a horizontal line *ii* through *h*. With *j* as centre on *de* draw a circle of radius equal to the leading edge radius (usually $0{\cdot}025w$) to touch *aa*. Draw two tangents to touch the two circles, the one with *t* as radius, the other of leading edge radius, the latter at *k* and *l*. Draw lines *km* and *ln* normal to these tangents.

The next stage may be carried out either by trial and error or by a construction. A point *o* is to be found on *ii* through which a circle will pass with centre *q* on *km*, to touch the leading edge circle *ak*, *qo* being normal to *ef*.

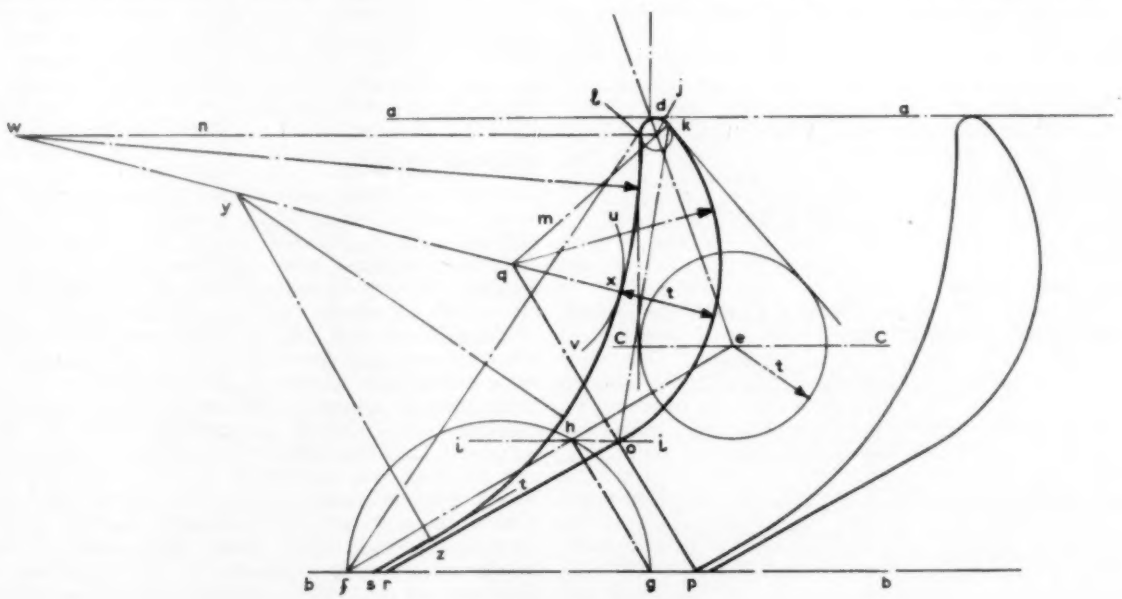


Fig. 23.—Turbine blades: method of construction

Thus $qk = qo$. The construction method is as follows. Measure λ the angle between the tangent at k and the line de. Then set off ko to make an angle of $\frac{1}{2}\{\beta_2-(\beta_1+\lambda)\}$ with the vertical. This gives o on ii correctly. Join qo and produce to p on bb. Draw or parallel to ef (r on line bb). Then kor forms the blade back. Draw st parallel to ro (s on bb), the two lines st and ro being the trailing edge thickness apart (usually 0·02 w). With q as centre draw circle uv, distant t, the blade thickness, from circle ko. By trial and error or by the usual construction (not described here) find the centre w on ln of a circle to touch the leading edge circle at l and circle uv. The latter point of contact is defined by joining wq and producing to give x on uv. Similarly find the centre y on wq of a circle to touch circle uv at x and line st. The latter point of contact is defined by drawing yz normal to st. Then the blade front is lx zs. The new chord line is ds approximately and a revised drawing could now be made using the more accurate chord length so measured. (Note that the point of contact z must not fall below s). It will be noted that p is the point on the adjacent blade corresponding to s on the drawn blade; op is the throat of the passage.

9.25. Blade modulus

The blade section above could be analysed geometrically to give the principal moments of inertia. Instead, however, the following approximation is given for the smallest modulus of typical turbine blades built up after the manner of sect. 9.24.

$$Z = \frac{\{10(t/c)_t\}^a}{b}\ c^3 \text{ in.}^3$$

Where c = chord, $b = 1420-9{\cdot}30$,
and $a = (272-\theta)/148$.

9.26. Bending moment on the blade

The tangential or peripheral bending moment at the blade root is

$$T.B.M. = \frac{QJk\Delta Th(s/c)_t c}{2\pi u_m d_t}$$

The axial bending moment is much less, may be $\frac{1}{5}$th of the *T.B.M.* but it is considered to be sufficiently accurate to assume that the vector sum of the two moments which accounts to $\sqrt{1+e^2}\ T.B.M.$ where $e = A.B.M./T.B.M.$, is exactly normal to the weaker of the two principal axes of the blade, which is also assumed to be parallel to the chord line so that $e = \tan\zeta.\tan\zeta$ is taken as $\frac{1}{2}(\tan\beta_2-\tan\beta_1)$ or measured from the drawing. Although this double approximation appears rough, it will not give rise to serious error in the calculated chord length.

9.27. Blade chords

This total *B.M.* is resisted by $f_b Z$, the Z being that given above in sect. 9.25, hence

$$f_b Z = \frac{(1+\tan^2\zeta)QJk\Delta Th(s/c)_t c}{2\pi u_m d_t \times 2240}$$

$$= \frac{(1+\tan^2\zeta)Qk\Delta Th(s/c)_t c}{10u_m d_t}$$

combining this with the Z equation of sect. 9.25 gives

$$c^2 = \frac{b}{(10t/c)^a} \cdot \frac{(1+\tan^2\zeta)Qk\Delta Th(s/c)_t}{10u_m\, d_t\, f_b} \text{ in.}^2$$

in which it is emphasized that $k\Delta T$ is Chu/lb. Q the gas flow lb/sec, h in., u_m ft/sec, and f_b ton/sq in.

9.28. Turbine length

Assuming the stage width (axially) is $2\frac{3}{4}$ times the blade width, $w = c\cos\zeta$ and $w_s = 2\frac{3}{4}\ c\cos\zeta$ to give $(w_s)_1$ for the first, and $(w_s)_2$ for the last stage. Turbine length, L = no. of stages $\times\ \frac{1}{2}\{(w_s)_1 + (w_s)_2\}$ inches.

To be continued.

Sealed Subminiature Switch

To meet the demand for a reliable and environment-proof subminiature switch, Honeywell Controls Limited, Greenford, have introduced a hermetically sealed switch measuring less than 0.14 cu in. The switch (IHMI) is interchangeable with Honeywell's standard SM series and its eight auxiliary actuators enable it to be adapted to fast, slow, cam and slide actuation. With its precision snap-acting mechanism protected by a hermetically sealed chamber, the new switch is for applications where reliability is all-important. The seal includes metal-to-metal fusion round the cover, actuator and mounting holes, and glass-to-metal seals around the terminals, which are potted in epoxy resin. The case is stainless steel. Electrical rating is 3 amp inductive, 5 amp resistive at 28V d.c. It has a minimum mechanical life of 25 000 operations, and will operate in temperatures from −229° C. to 121° C. A further version suitable for 200° C operation is shortly to be announced.

Wire and Cable Ducting

A new type of diagonally slotted rectangular ducting made of a special P.V.C. material is now being imported by Shawford Control Gear Company Limited, 715 Tudor Estate, Abbey Road, Park Royal, London NW10, under the name "Duct-Plast". Manufactured by "CEMA", Italian producers of equipment, it is available in 2 metre lengths, with cross sections of from 40 mm × 15 mm to 80 mm × 60 mm. Among its advantages are its ability to retain its dimensions and characteristics over a wide range of ambient temperature, from −20° C. to 105° C, and is flame proof, non-hygroscopic and has long life. A feature is the "snap-on" cover that provides a close fit without the use of metal clips, and the more completely the ducting is filled with wires, the tighter the cover fits. The diagonal slots enable the wires to be brought out exactly opposite the terminals or tags to which they are to be attached.

Air Filters

The "Miniroll" filter newly added to the range made by Vokes Limited, Henley Park, Guildford, is a compact unit based on the Autoroll Mk II: with the important addition of having a 'square' air flow aperture. It can be installed horizontally or vertically and servicing can be carried out outside the ductwork. In operation a length of clean fibrous back filter medium is passed automatically from one spool across the air flow to another spool. An electrical system controls the movement which can be actuated by a pressure differential switch or timer as required. The 'Miniroll' is manufactured in two sizes only: 4 ft high (for attachment to 22 in. square duct) and 5 ft high (for attachment to 34 in. square duct). The two sizes give capacities of 1000—2000cfm and 2000—4000 cfm with an initial efficiency of 98% against Test Dust No. 2 (B.S. 2831) with minimum and maximum operating resistance of 0·2 in.—0·7 in. wg depending on the technical characteristics of the installation.

Screw Thread Standards

A standard screw thread is simply one which conforms to an adopted contour of thread and pitch and number of threads per inch for given screw diameters. The first attempt at rationalization was the Whitworth thread a century ago. Other countries, notably America and Continental Europe, evolved their own standards. Rationalization of English unit threads was eventually realized with the 'Unified' standard, and a similar and parallel international standard for metric threads is still under discussion. This article discusses the evolution of thread standards and the present position

THE origins of the screw thread as a form of fastener are obscure. Certainly threaded forms were in use well over a thousand years ago to improve the 'grip' of metal nails but their first authenticated application as fasteners in their own right, mating with a matching female thread, comes very much later. By the early part of the nineteenth century, however, the threaded fastener (principally the nut and bolt) was firmly established, although the thread forms used varied widely and were largely dependent on the individual skill, and preference, of the craftsman. Many were hand chased and varied from unit to unit. The engineer of those days largely made his own nuts and bolts rather than purchase them as 'stock' items.

Obviously this was an unsatisfactory arrangement, particularly as it marked the start of a period of manufacturing engineering which accelerated in growth and scope throughout the century, and also opened up the market for the specialist manufacturer dealing in components rather than completed products. A serious attempt to rationalise screw thread production was undertaken by Sir Joseph Whitworth about 1841 who, after a study of existing thread types and forms, proposed the Whitworth thread as an optimum form for standardization throughout the engineering industry. Over the next twenty years the Whitworth thread did, in fact, displace the existing miscellaneous collection of threads in general use and established itself, together with a fine thread series of the same form, as the basic thread standard for British engineering for over a century.

The standard Whitworth thread form was based on a 55° angle between the flanks with a specified rounding at crest and root and varied only in the number of threads per inch and embraced also the British Standard Fine (B.S.F.) and Whitworth Watch and Instrument Threads. It is also used for pipe threads.

Some twenty years after the introduction of the Whitworth thread—in 1864 to be exact—Sellers quite independently proposed another standard in America which became adopted as the American Standard (U.S.S.), subsequently developed into the American National Coarse (N.C.) and National Fine (N.F.) threads. The original Sellers thread specified a 60° angle between the flanks and cut off rather than rounded crests and roots, this form being simpler to make. It was originally adopted in the S.A.E. and A.S.M.E. standards.

At the same time metric thread standards were being adopted on the Continent, most of which used the cut-off V-shape but with a different angle between the flanks to the Sellers or the Whitworth. The Loewenherz (German) thread, for example, was based on a 53° 8′ angle between the flanks; and the Thury (Swiss) thread a 47½° angle. The International (Metric) Standard Thread, however, eventually evolved as a 60° angle and flat crests and rounded roots.

For all general engineering the Whitworth form became the standard for Britain, the Sellers for America and the S.I. Metric for Continental Europe, although some variations of the S.I. Metric were introduced by different countries. At the same time a number of other standard threads were introduced for specialized applications. Square threads, for example, offer advantages in certain applications and are easier to cut than other forms. They have remained a standard form although they are not as strong as the Acme thread with a 29° angle between the faces. The Acme shape is also better suited for worm threads than standard forms, although worm threads are usually deeper and have the corners of the thread at root and crest radiused.

Both the Square and Acme are recognized as standard thread forms, together with others such as the British Association (B.A.) thread with a 47½° angle and rounded crest and root; the British Standard Cycle Thread (B.S.C.) and Cycle Engineers Institute (C.I.E.) American equivalent, both with 60° angle and rounded crest and roots; British, American and Continental Pipe Threads; and various others, together with special threads for watchmaking, model engineering, and so on. Even the S.I. (Metric) was not exclusively adopted on the Continent. The S.F. French thread followed the U.S. Standard; and the French Metric threads differ from the S.I. system above 100 mm size. The German metric thread followed the S.I. standard between 6 and 12 mm, but with slightly different proportions in other sizes.

A century after Whitworth introduced the first 'universal' screw thread standard, in fact, the existence and widespread use of some eight other major standards nullified the obvious advantages to be gained by rational standardization. The need for a common standard between Britain and America, at least, was recognized by the end of World War I, but it was not until some thirty years later (November 1948) that the current Unified thread was agreed upon by Britain, the United States and Canada, to be used as the future (single) standard for all countries employing inch units.

Agreement on a world basis has still to be reached, although the International Organization for Standardization has issued draft recommendations which, it is hoped, will form the basis of a completely International standard. These recommendations have been based on two series—one covering inch sizes of screw threads from 0·060 in. up to 6 in.; and the other covering a metric series from 0·25 mm up to 300 mm. Both series employ the Unified thread profile.

The present position is that Unified threads are

accepted as the only standard for new productions in a number of major industries in Britain and America. In Britain this embraces the automobile and agricultural industries, chemical engineering and the oil industry, and to a lesser extent, as yet, the aircraft industry. General engineering still widely employs B.S.W. and B.S.F. threads and change to Unified threads still tends to be slow—particularly bearing in mind that the Anglo-American agreement to adopt the new thread is now nearly fourteen years old. Other industries stick to their original standards—B.A. threads for electrical components, for example. Thus although theoretically obsolescent, total demand for B.S.W., B.S.F. and B.A. threads still greatly exceeds Unified thread production in Britain.

In the United States the American National (A.N.) series are obsolete and all the latest standards for screw threads are completely unified and interchangeable with the British Unified threads. General adoption of the Unified threads appears to be far more widespread there.

On the Continent the S.I. (Metric) thread remains the common standard and seems likely to hold this position for many years to come, even if agreement is reached on the proposed I.S.O. Metric Standard. Some Continental manufacturers will, however, fit Unified (inch size) threads on individual productions to meet a customer requirement and others recognize the desirability, at least, of an overall world standard. As regards servicing and replacement difficulties on exports to 'English unit' markets, however, spares and special tools can often be a profitable line to the originators when contracted through concessionaires and foreign distributors. Complete world standardization, in fact, is quite impossible without a single world standard unit of measurement—and that is an entirely different subject and a matter of even greater controversy than screw thread standards.

Nuclear Fuels for Power Stations

Types and properties

By J. R. FINNIECOME, M.Eng., M.I.C.E., M.I.Mech.E., F.Inst.F., Consulting Engineer

1. Introduction

DURING the past decade remarkable achievements have been made in nuclear technology, metallurgy and in chemical engineering. A decisive part has been the production of economically attractive nuclear fuels and a formidable series of studies continues in progress at various research establishments in many countries of the world, the primary object being the improvement of the overall thermal performance of the reactor by operating it at much higher temperatures. This has the desired advantage of increasing particularly the pressure and the temperature at the stop valve of the prime mover, thus decreasing the total capital cost per kilowatt of installed generating capacity, and also the overall cost per unit sent out.

2. Types of nuclear fuel

A summary of the nuclear fuels at present used is given in Table I. These can be divided into two main groups, metallic and ceramic fuels. The metallic fuels are either fertile, such as uranium U238 and thorium Th232, or fissionable, as for instance uranium U235, uranium U233 and plutonium Pu239. A remarkable characteristic of U238 and Th232 is that when bombarded by neutrons in a reactor, each will absorb some of the neutrons and react to form the new fissionable nuclear fuels Pu239 and U233. These fertile and fissionable materials can be formed into a variety of shapes, such as rods, pellets, tubes, sheets, powder and liquid, for use in a reactor. A more recent development is ceramic nuclear fuel which has the fertile or fissionable materials in the form of oxide or carbide. (Table II, groups 1 & 2). In addition there are dispersed nuclear fuels consisting of a mixture of, for example, UC/ThC, UO_2/ThO_2, UO_2/ThC_2 and UO_2/PuO_2 (Table II group 3).

Research programmes on various types of nuclear fuels and suitable canning materials are in progress to improve the overall performance of nuclear power stations. The major problems which have to receive special attention when considering the merits of nuclear fuel are high fuel and canning temperatures, greater specific reactor fuel rating (expressed in MW per tonne

Table I.—METALLIC NUCLEAR FUELS

1	2	3	4
Group	Types of Fuel	Chemical Symbol	General comments
1	Fertile Natural Uranium	U238	Discovered by the German chemist M. H. Klaproth (1743-1817) in 1789. First prepared by the French scientists E. Péligot (1811-1889) in 1841. Principal source is pitchblend (or uraninite), essential constituent being uranium oxide (UO_2). Named after the planet uranius. Contains 99.28% U238, 0.71% U235 (fissionable) and 0.0058% U234 (fissionable)
	Thorium	Th232	Discovered in 1828 by the Swedish scientist J. J. Berlelius, (1779-1848). Named after Thor, the Scandinavian god of war. Occurs chiefly in monazite and in thororite ($ThSiO_4$) Contains 3 to 9% thorium dioxide (ThO_2)
2	Fissionable Uranium U233	U233	Produced by nuclear bombardment of thorium Th232.
	Uranium U234	U234	Contained in U238 (0.0058%)
	Uranium U235	U235	The only naturally-occuring nuclear fuel isotope of uranium, which occurs as about 0.71% U235 in natural uranium U238.
	Enriched uranium	U235	With percentage above 0.71 and up to 95. Produced by the gaseous diffusion process since 1945.
	Plutonium	Pu239	Named after the Planet Pluto, next in order beyond Uranius. Produced by neutron bombardment of U238 in the reactor. The most important isotope of plutonium. First discovered in 1941 at the Berkeley University by G. T. Seaborg, E. Segre, J. W. Kennedy and E. O. Lawrance. It is the daughter of 2.3-day neptunium (Np239) and has a half life 24,100 years.
	Uranium alloys Plutonium alloys		

of nuclear fuel) and increased burn up in the reactor, defined as megwatt-day (Mwd) per tonne of nuclear fuel.

3. Nuclear fuels used in power stations

The fuels actually used in nuclear power stations, in operation and construction in various countries of the world, are presented in Table III & IV. The stations using the same fuels are arranged in groups, as indicated in column 2.

The salient facts emerging from the Tables are:

(a) All the graphite moderated and carbon dioxide cooled reactors in Great Britain use natural uranium.

(b) It follows from this that Great Britain has concentrated on one type of reactor, i.e. the Calder Hall type for nuclear power stations.

(c) The French stations have graphite moderated and gas cooled reactors, fuelled with natural uranium.

(d) It is apparent that the predominant fuel is natural uranium for it is used in twenty-two nuclear stations in the world, twenty of these are gas cooled, of which nineteen have carbon dioxide, and one at Marcoule (G1) has air as coolant.

(e) Eleven nuclear stations are fuelled with enriched uranium dioxide.

(f) Six stations use natural uranium dioxide as fuel.

(g) There is only one nuclear power station using each of the fuels.

(1) enriched uranium (Riva Triboso, Italy).

(2) enriched uranium Mo alloy (The Enrico Fermi fast breeder sodium cooled power reactor at Lagoona Beach, Lake Erie, near Detroit, U.S.A.)

(3) enriched uranium + UO_2 with an enrichment of 90% U235 (Shippingport, Pennsylvania.)

(4) enriched uranium monocarbide with an enrichment of 20% U235. (Stetternich, near Julich, west of Cologne, Germany.)

(5) mixture of UO_2 and ThO_2, thus providing for U233 to extend the fission life of the fuel. The first commercial reactor to use thorium (Indian Point, near New York, owned by Consolidated Edison Company. First nuclear power station to introduce a separately oil-fired superheater. Also the first privately owned nuclear power station in the U.S.A.)

(h) The U.S.A. nuclear power stations at Rowe, Massachussetts, owned by the Yankee Atomic Electric Company and at Dresden, near Chicago of the Commonwealth Edison and others are the first to have enriched uranium dioxide as fuel.

(i) The maximum total net output of a nuclear station is 580 MW for Sizewell and the highest thermal efficiency is 32·9% for Dungeness.

Table II.—CERAMIC NUCLEAR FUELS

Types	Chemical Symbol
1. Dioxides	
(a) Natural uranium dioxide	UO_2
(b) Enriched uranium dioxide	UO_2
(c) Thorium dioxide	ThO_2
(d) Plutonium dioxide	PuO_2
2. Carbides	
(a) Uranium monocarbide (natural or enriched)	UC
(b) Uranium dicarbide (natural or enriched)	UC_2
(c) Thornium monocarbide	ThC
(d) Thorium dicarbide	ThC_2
(e) Plutonium dicarbide	PuC_2
3. Dispersed	
(a) UC/ThC	
(b) UO_2/ThO_2	
(c) UO_2/THC_2	
(d) UO_2/PuO_2	

4. Operating characteristics of nuclear fuels

The primary factors that influence the performance of nuclear power stations are briefly:

(a) the maximum permissible fuel temperature

(b) the maximum permissible can surface temperature

(c) the mean fuel rating of the reactor expressed in MW(h) per tonne of fuel.

(d) the average and the maximum burn up.

Current practice for twenty-six stations is summarized in Table V, examination of the values contained in the table reveals:

(1) The optimum fuel temperature for the fifteen nuclear power stations using natural uranium as fuel is 1085° F whilst for those having either natural or enriched uranium dioxide or a mixture of uranium dioxide and thorium dioxide, i.e. ceramic fuels this temperature is about 4000° F, with 4655° F for Yankee nuclear power station.

(2) The maximum can surface temperature is 859° F (Hunterston, item 5.)

Table III.—PARTICULARS OF NUCLEAR POWER STATIONS USING NATURAL URANIUM

1	2	3	3	4	5	7	8	9	10	11	12	13	14
				Reactor			Turbogenerator						
Item	Country	Location	Year in commission	Number of reactors	Total heat rating MW(H)	Heat rating of each reactor MW(H)	Number	M.C. rating of each set MW(e)	Total gross generating capacity MW(e)	Total net output MW(e)	Moderator	Coolant	Net station thermal efficiency % units s.o.
1	Great Britain	Calder Hall A & B	1956/58	4	720	180	8	23	184	140	Graphite	Co_2	21·5
2		Chapelcross A & B	1958/59	4	720	180	8	23	184	140	"	"	21·5
3		Berkeley	1962/63	2	1100	550	4	83	332	275	"	"	24·4
4		Bradwell	1962/63	2	1060	530	6/3	52 + 5%/ 20·5	389·1	300	"	"	28·2
5		Hunterston	1963/64	2	1060	530	6	60	360	320	"	"	28·0
6		Hinkley Point	1962/63	2	1972	986	6/3	93·5/33	660	561	"	"	26·4
7		Trawsfynydd	1963/64	2	1740	870	4	145	580	500	"	"	28·7
8		Dungeness	1964/65	2	1670	835	4	142·5	570	550	"	"	32·9
9		Sizewell	1965/66	2	1900	950	2	345	650	580	"	"	30·5
10		Oldbury upon Severn	1967/68							560	"	"	
11		Wylfa (Anglesey)	1968/69							800	"	"	
12	France	Marcoule (G1)	1956	1	40	40	1	5·75	5·75	5	Graphite	Air	
13		Marcoule (G2)	1958	1	150	150	1	40	40	28	"	CO_2	16·0
14		Marcoule (G3)	1959	1	150	150	1	40	40	28	"	"	16·0
15		Chinon (EDF-1)	1962	1	290	290	1	82	82	60	"	"	22·7
16		Chinon (EDF-2)	1963	1	700	700	2	125	250	170	"	"	24·9
17		Chinon (EDF-3)	1964	1	1200	1200	2	280	560	375	"	"	
18		Chinon (EDF-4)	1965				2	250	500	400	"	"	
19	Norway	Halden (First core)	1959	1	5	5		no	no	process	D_2O	D_2O	
20	Italy	Latina	1962	1	705	705	3/2	70/9·5	238·5	200	Graphite	CO_2	28·4
21	Japan	Tokao-Mura	1963	1	500	500	2	85	170	150	"	"	27·7
22	Canada		1965	1						153·6	DO_2	organic liquid	

Table IV.—PARTICULARS OF NUCLEAR POWER STATIONS USING

1	2	3	4	5	6	7	8	9	10	11	12	13
								Reactor				
Item	Nuclear fuel	Enrichment in % U235 %	Country	Location	Designation	Type of reactor	Year in commission	Number of reactors	Total heat ratings MW(H)	Heat rating of each reactor MW(H)	Moderator	Coolant
1	Enriched uranium		Italy	RivaTriboso	—	PWR	1963				H_2O	H_2O
2	Enriched uranium Mo alloy	25% U235	U.S.A.	Lagoona Beach	—	FBR		1	430	430	—	sodium
3	Enriched uranium + UO_2	90% U235	U.S.A.	Shippingport	—	PWR	1957	1	232	232	H_2O	H_2O
4	Natural uranium dioxide	nat	France	Monts d'Arree	EL4	D_2O/CO_2	1964	1	225	225	D_2O	CO_2
5	" " "	"	Sweden	Marviken	R4-Eve	D_2O	1967	1	400	400	D_2O	D_2O
6	" " "	"	Sweden	Simpevar	—	BWR	1965	1			D_2O	D_2O
7	" " "	"	Canada	Douglas Point	Candu	D_2O	1965	1	698	698	D_2O	D_2O
8	" " "	"	Canada	Rolphton	NPD-2	D_2O	1962	1	82·5	82·5	D_2O	D_2O
9	" " "	"	Canada		OCDR			1			D_2O	santawax OM
10	Enriched uranium dioxide	3·29/4·43	Belgium	Mol	BR3	PWR	1960	1	43	43	H_2O	H_2O
11	" " "	3·1	France/Belguim	Chooz	—	PWR		1	825	825	H_2O	H_2O
12	" " "	2·3/2.6	Germany	Kakl on Main	—	BWR	1960	1	57	57	H_2O	H_2O
13	" " "		Italy	Garigliano	—	DPBR	1963				H_2O	H_2O
14	" " "		Italy	E. Fermi P.S.	—	PWR	1963	1			H_2O	H_2O
15	" " "		Italy	Ponta Fiume	—	DPBR	1965				H_2O	H_2O
16	" " "	1·5	Norway	Halden (OEEC)	—	D_2O	1962	1	20	20	D_2O	D_2O
17	" " "		Sweden	Agesta	R3-Adam	D_2O	1964	1	65	65	D_2O	D_2O
18	" " "		Switzerland	Zurich (ETH)	—	D_2O		1	30	30	D_2O	D_2O
19	" " "	2·29/3·02	U.S.A.	Yankee (Rowe)	—	PWR	1960	1	392	392	H_2O	H_2O
20	" " "	1.5% U235	U.S.A.	Dresden	—	DPBR	1960	1	624·2	624·2	H_2O	H_2O
21	Enriched uranium monocarbide	20%U235	Germany	Stetternich	—	HTGR	1962	1			Graphite	Helium/ NEON
22	Mixture of UO_2 and ThO_2		U.S.A.	Indian Point	—	PWR	1962	1	585	585	H_2O	H_2O

(3) The optimum values for the mean fuel rating of the reactor are:

Fuel	MW(h)/ tonne	Item
(a) natural uranium	3·314	15
(b) enriched uranium dioxide	17·26	24
(c) mixture of UO_2 and ThO_2	68·42	26

(4) The expected average burn up:

(a) natural uranium, graphite moderated and carbon dioxide cooled reactors	3000 to 4500	MWd/t
(b) natural uranium heavy water moderated and carbon dioxide cooled reactor (item 17).	6000	,,
(c) natural uranium dioxide, heavy water moderated and cool reactor (item 18, Douglas Point, Canada)	9750	,,
(d) mixture of UO_2 and ThO_2, pressurized light water moderated and cooled reactor (item 26, Indian Point, U.S.A.)	10000	,,

(5) The optimum life of fuel is 10060 hours for the nuclear power station Yankee, U.S.A. (item 24).

(6) The cladding materials in relation to fuel are:

(a) natural uranium	Magnox A12 Mg-Zr alloy
(b) enriched uranium and ceramic fuels	Zircaloy-2 Zircaloy-4 Zirconium Stainless steel

Table V.—THE DESIGN DATA OF REACTORS

1	2	3	4	5	6	7	8	9	10
			Temperature			Burn up			
Item	Fuel	Country	Location	Fuel Min. Mw(h)/T	Rating Max. °F	Can Max at surface °F	Expected average Mwd/t	Maximum Mwd/t	Life of fuc. hr	Cladding Material
1	Natural uranium	Great Britain	Calder Hall A & B	1·385	752		3000			Magnox A12
2	" "	"	Chaplecross A & B	1·385	752		"			"
3	" "	"	Berkeley	2·201			"			"
4	" "	"	Bradwell	2·209	1017			4500		"
5	" "	"	Hunterston	2·110	1076	859	3600	4500		"
6	" "	"	Hinkley Point	2·665	1040	805	3100	4500		"
7	" "	"	Trawsfynydd	3·171		824	4500		5 years	"
8	" "	"	Dungeness	2·802	1040	828				"
9	" "	"	Sizewell	2·959						"
10	" "	France	Marcoule (G1)	0·400						magnesium
11	" "	"	Marcoule (G2 & G3)	1·333						Mg-Zr Alloy
12	" "	"	Chinon (EDF-1)	2·174	1022	752				" "
13	" "	"	Chinon (EDF-2)	3·162	1085	795				" "
14	" "	Italy	Latina	2·685	1085					Magnox A12
15	" "	Japan	Tokai Mura	3·314						"
16	Enriched uranium + UO_2 (90%U235)	U.S.A.	Shippingport	16·34	3800		3000		8000	Stainless steel
17	Natural uranium dioxide (nat)	France	Monts d'Arree	10·76			6000			
18	" " " "	Canada	Douglas Point	14·82	4000	547	9750			Zircaloy-4
19	" " " "	Canada	Rolphton	5·22	4000	547	4300			Zircaloy-2
20	Enriched uranium dioxide (2·3/2·6)	Germany	Kahl on Main	10·36						
21	" " " (1·5)	Norway	Halden	13·71						
22	" " " "	Sweden	Agesta	3·64			2800			Zircaloy-2
23	" " " "	Switzerland	Zurich (ETH)	6·00						Zirconium
24	" " " (2·29/3·02)	U.S.A.	Yankee (Rowe)	17·26	4655	651	8208		10060	Stainless steel
25	" " " (1·5)	U.S.A.	Dresden							Zircaloy-2
26	Mixture of UO_2 and ThO_2	U.S.A.	Indian Plont	68·42	4000		10000		4320	Zircaloy-2

VARIOUS FUELS

14	15	16	17	18	19
	Turbogenerator				
Cladding of fuel element	Number	M.C. rating of each set MW(e)	Total gross capacity MW(e)	Total net capacity MW(e)	Net station thermal efficiency %
	1			135	
zireonium	1	156	156		
zircaloy-2	1	100	100	90	
stainless steel	1	84	84	70	32·0
zircaloy-2	1			100	
	1			60	
zircaloy-4	1	220	220	203	
zircaloy-2	1	22	22	17	
	1			153·6	
stainless steel	1	12	12	11·5	
	1	258	258	242	29·3
	1	16	16	15	
zircaloy-2	1	160	160	150	
	1			160	
	1			150	
zircaloy-2				process	
zircaloy-2	1	12	12	10	
	1			5	
stainless steel	1	145	145	134	
	1	192	192	180	28·7
	1			15	
zircaloy-2	1	275	275	255	31·91

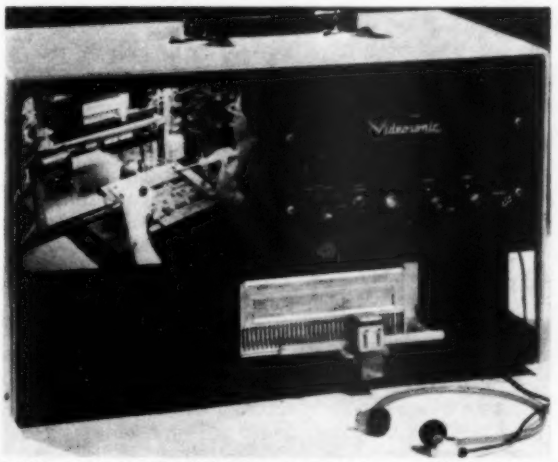
The main disadvantages of metallic fuels is that they can only be used at a comparatively low temperature which limits the efficiency of fuel cycle. To obtain higher specific ratings from the reactor it is imperative to use materials which can withstand much higher central temperatures. In such cases ceramic fuels are employed. Of these uranium dioxide, either natural or enriched, is at present the most favoured for its irradiation and crystallographic stability, relative chemical inertness to proposed coolants and low thermal neutron absorption cross section.

Enriched uranium dioxide was the first ceramic fuel. This spectacular development originated in the U.S.A. and was applied to the pressurized light water reactors at Shippingport (1957), Rowe (Yankee) and Dresden (1960) and finally Indian Point (1962). The first station in Europe to have enriched uranium dioxide was at Mol, Belgium. It has a pressurized light water reactor. The net generating capacity is only 11·5 MW(e) and it was in operation in 1960. The number of stations in commission in 1965 with enriched unranium dioxide will be eleven. The UO_2 is prepared as short cylindrical pellets, which are inserted in a long tube to form a rod. Typical dimensions are:

Power station	Dimension of pellets diameter in.	Dimension of pellets length in.	Material of tube
Yankee (Rowe, U.S.A.)	0·290	0·600	stainless steel
Mol (Belgium)	0·300	0·600	" "
Kahl (Germany)	0·500	0·630	Zircaloy

The pellets are produced by cold pressing the powder in a press following firing. Binder and lubricant are usually added before pressing as in conventional ceramic practice. The important parameter is the density of loading UO_2 in the fuel rod which should be 90% and over. UO_2 is a very refractory material with a melting point of 2750° C (4982° F). The thermal conductivity is not high. consequently the radius of the pellets represents an appreciable barrier to heat flow. In addition, there is usually no attempt to provide a bond between the pellet and the metal tube.

To be continued.



The Videoscope in use. The display shows the operator an assembly sequence, one stage at a time

Operation Training Unit

The Videosonic system of audio-visual presentation was originally developed to solve a specific problem related to the production of complex electronic assemblies. On the assemblies in question no amount of written planning, wiring diagrams or drawings had been able to present wire routing and component placement accurately and in a manner that could be readily understood by the assembly personnel, or in a manner that did not demand time consuming and error prone decisions. The Videosonic system provided operators with step by step illustrations of the assembly, on an illuminated screen at a convenient working position, simultaneously with precise audible instructions relative to each stage of the work.

The system has been extended to other applications and the equipment has been extensively redesigned to ensure efficiency and flexibility. The unit illustrated is portable and weighs only 23 lb but can be conveniently built into a production work station or training bench. It incorporates a magnetic tape play-back unit, a back projection unit, automatic slide change mechanism and the electronic circuitry necessary to provide complete synchronization between the audible and visual presentations. A complete service for the supply and application of the unit is provided by Audio Visual Methods Limited, Cordwallis Industrial Estate, Maidenhead.

Bright Copper Plating

Mirror-like copper deposits are now possible following the introduction of a new bright acid copper plating process by Electro-Chemical Engineering Company Limited, of Sheerwater, Woking. Designated UBAC, the new process utilizes a conventional air agitated acid copper plating solution to which one brightener, UBAC No. 1, is added. Ductile and with good levelling properties, the deposit is bright over the whole current density range. At 50 amp per sq ft an average thickness of 0·001 in. can be produced in 22 min.

Vinyl Film, Sheet and Coatings

As one of the more 'inert' plastics, vinyl has considerable applications for coatings and also for the production of covering materials. Various types of vinyl coatings are described, ranging from films to thick coatings. 'Strippable' coatings are also an important type for the temporary protection of tools, machine parts, etc., during transport or storage

VINYL elastomers, derived by plasticizing the hard bone-like resin vinyl chloride, offer a range of tough, flexible plastics with a valuable combination of properties not available with other materials. Chief properties of the vinyl elastomers are chemical inertness and good electrical properties. The physical properties can be enhanced or 'tailored' in a particular direction, as required, by compounding, although this is usually accompanied by a certain loss of chemical and electrical characteristics.

Film and sheeting is relatively easy to produce, normally by calendering through three or four heated rolls. The plastic is fed to the calender whilst still hot and a temperature gradient maintained on the rolls so that the plastic follows the proper path without sticking. Where uniform thickness is required, close temperature control is essential, particularly in the production of film of the order of 0·004 in. thickness.

Colouring can be introduced by incorporating suitable pigments into the compound during milling, or coloured patterns can be printed on the plastic with vinyl inks after calendering. Embossing can also be done on the final roll—a lightly embossed roll producing a frosty appearance, or additional rolls are used where a heavier embossed pattern is required.

Vinyl sheet (and film) is also produced as a laminate, normally referred to as supported sheeting. In this case the sheet (or film) is calendered or spread-coated on a fabric or paper backing. When done during calendering the fabric or paper backing is usually run through the last two rolls of the calender simultaneously with the plastic which, being warm, bonds readily to the backing material. Apart from increasing the mechanical strength of the film, supported sheeting may also be used to produce special decorative effects, or serve a functional purpose. It is easier to bond supported sheeting to other surfaces, for example, by straightforward gluing techniques.

Thicker sheeting in the form of tiles, etc., is particularly suitable for heavy-duty floor coverings and similar duties. Whilst some thick sheeting is produced by calendering, alternative methods which may be used are moulding and extrusion. Composite construction may also be employed to reduce manufacturing cost, such as laminating with low-cost backing materials which supply the bulk of the thickness.

Thin sheet and film is also produced by extruding and blowing. The initial product is tubing which is then expanded by blowing to reduce the wall thickness to the required figure. The tubing may then be slit and opened up to form sheeting or film, or heat-sealed to form bags, envelopes, etc. Yet another method of producing film is by 'casting' where the liquid plastic is poured on flexible metal sheets and subsequently stripped off when set.

Surface coatings may be applied by a variety of methods. Functional coatings are used for water resistance or water-repellance, protection against grease, chemical attack, etc., and also to improve the tear resistance of the base material. Vinyl films have the advantage of retaining excellent flexibility down to very low temperatures (of the order of −70° F) and very low rate of water vapour transmission.

Heavy functional coatings are used for a wide variety of duties, such as coating industrial gloves, plating racks, processing dishes and containers, etc., chemical tank linings, and so on. Thick coatings of this type are usually applied by dipping or spreading, followed by fusion at a temperature of about 350° F. Heavy 'dip' coatings are also used for the protection of tools and similar equipment during storage or transport, when the adhesion of the film is controlled by the formulation to produce a coating which is readily 'strippable'.

Another interesting form of plasticized vinyl is a semi-solid or putty-like composition known as a plastigel which can be applied by trowelling (e.g. as a surface coating or tank lining) and fused in place at 350° F.

Ordinary solution coatings are formulated on a variety of resin and solvent mixtures, usually air-drying to form a continuous film. The usual characteristic of this type of coating is a high gloss finish and, since pigments are rarely used, complete transparency of the film. Such coatings are mainly used for decorative effects—e.g. to enhance gloss and underlying colour—but at the same time offer definite protection to the base surface against water, grease, chemical staining, etc.

Latice coatings are water dispersions of special vinyl resins which can be applied to produce thin coatings without having to employ volatile solvents. They are thus particularly suited for application in industries where water systems are already in use—e.g. paper manufacture—or where toxicity and fire hazard must be avoided.

Other vinyl coatings may be applied in the form or hydrosols, organosols or plastisols. The properties in all three cases are similar but one or other may offer specific advantages in a particular production line or application. Hydrosols are, again, essentially water dispersions containing no volatile solvents and are suitable for application by conventional coating methods and equipment. Plastisols are paste-like dispersions of the resin in liquid plasticiser (midway in consistency between solutions and plastigels), once more containing no volatile solvents. Their particular advantage over solution coatings is that they enable the required thickness of film to be built up with a single application. One plastisol coat can easily build up a thickness which could only be obtained with six or eight solution coats.

Organosols are somewhat similar to plastisols, except that a volatile solvent is incorporated to enhance the 'flow' characteristics. The proportion of volatile constituent may vary between 2% and 20%, depending on the particular duty required. Organosols are employed for producing both thin and thick coatings. In the latter case a single application can build up a film thickness of about one half that practicable with plastisols.

Battery Power and Comparisons

The choice of battery for a given duty is often dictated by space or weight requirements. On an energy-ratio basis, silver-electrode alkaline accumulators show considerable superiority over lead-acid and nickel-iron or nickle-cadmium accumulators, but have higher initial cost and cost per cycle. Factors affecting battery performance and selection are discussed in this article, together with future developments likely with fuel-cells and the application of water-activated silver-magnesium cells. Standard forms of accumulators are also evaluated on a cost/energy basis

ALTHOUGH the application of batteries as a convenient, simple source of electrical power is increasing, the bulk of demand is met by primary cells or storage cells (accumulators) of orthodox and well known form—so orthodox, in fact, that there have been few changes other than in detail design for a considerable period. All standard forms of dry battery are based on the Leclanché cell and the only major change has been in the production of more numerous types and sizes, and particularly miniaturized high voltage dry batteries and compact batteries for use with transistor circuits. In the latter case the dry battery is a logical choice. Voltage required is usually relatively low and current demand small—both factors consistent with the demands for maximum efficiency from a Leclanché-type cell.

In the case of accumulators, lead-acid batteries are still a normal first choice because of the high cell voltage although at a disadvantage where compactness and weight saving are important. The alkaline accumulators have a distinct advantage in this latter respect, and other specific advantages, although producing only 1·2 volt per cell and costing more. Nickel-iron batteries are principally attractive as traction batteries and storage batteries for lighting, etc., where they may be anticipated to show from three to five times the life of a comparable lead-acid battery.

The nickel-cadmium battery is essentially similar in type and construction but the use of cadmium in the negative plate results in a lower internal resistance and lower charging voltage requirement. Such cells are therefore particularly useful where high rates of discharge may be encountered and must be maintained at an appreciably constant voltage level; and also for duties where the difference between discharge and charge voltages must be kept to a minimum. From being relatively large 'work' batteries, nickel-cadmium cells in particular are now produced as completely sealed in miniature and even sub-miniature sizes for a variety of industrial and scientific applications.

Silver-zinc and silver-cadmium cells are another type produced mainly in small and miniature sizes, chiefly on account of higher cost, but which offer specific advantages because of their robust nature, high-energy ratio, and capability of standing up to high current drain. Useful working life is, however, very much lower than that of other types of accumulators. Typically, in the case of a silver-zinc cell, this may range from as low as 50-60 cycles up to about 200 cycles, depending on the type of duty. In the case of silver-cadmium cells a normal maximum life is of the order of 500 cycles. Comparative figures for other cells are given in Table I. These data are, of course, only a generalization as the useful life of any storage cell is dependent on service conditions and the manner in which the cell is maintained. The life of a lead-acid cell is reduced drastically by lack of attention, but this is usually less apparent with alkaline accumulators. Nickel-iron and nickel-cadmium cells are sometimes claimed as 'indestructible' on account of the fact that their normal service life extends to several thousands of cycles stretching over periods of up to twenty years or more.

The more exotic types of batteries have yet to be developed fully for industrial applications. Fuel cells are now no novelty for they have been in a state of development for at least ten years. The fuel cell is still an electro-chemical battery but in this case the 'active' materials are kept outside the cell itself and fed in continuously when a continuous discharge is required. The electrodes or interior components of the battery are really nothing more than catalysts assisting in the transformation of the chemical activity of the fuel and oxidant introduced into the cell into electrical energy.

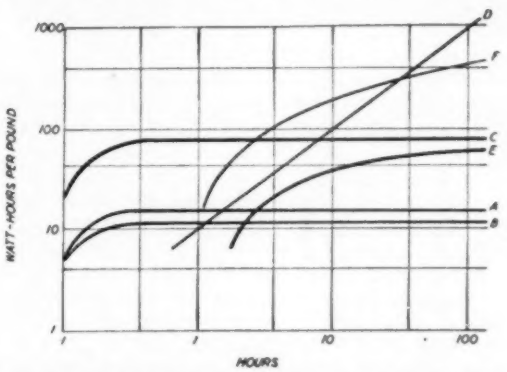


Fig. 1.—Diagrammatic representation of watt-hour per lb rating for typical standard accumulators compared with fuel-cells. A, lead-acid accumulator; B, nickel-iron accumulator; C, silver-cadmium of high-efficiency silver-zinc accumulator; D, solar convertor; E, solar convertor with battery; F, solid fuel cell (hydrogen-oxygen)

Table I.—BATTERY ECONOMICS
(TYPICAL FIGURES FOR 12 VOLT BATTERIES, 80-100 AMP HOURS CAPACITY)

Battery	Type	Typical Life		Typical* Initial Cost	Cost* Life Ratio	Cost* per Cycle
		Cycles	Years			
Lead-acid	Car type	250–300	3	100	33	·33
,, ,,	Heavy duty	1000–1500	5–6	160	33	1·3
,, ,,	Industrial	1500–2000	5–10	180	20	1·0
Nickel-iron	Heavy duty	2000–3000	15–20	320	20–16	1·3
Nickel-cadmium	Standard	2000–3000	10–20	370	37–18	·18
Silver-cadmium	,,	500	2–3	2500	1300	5
Silver-zinc	,,	200	1	2000	2000	10

Initial cost of Lead-Acid battery—100

Fuel cells do not normally show any advantages over conventional batteries, except where long periods of continuous discharge are required. The efficiency rating of the cell, in terms of watt-hours per pound weight of cell, goes on rising in the case of a fuel cell—see Fig. 1—whereas it remains at a more or less constant level over the normal discharge period for conventional accumulators. There are, of course, many different possible types of fuel cells, some of which become extremely complex and prohibitively expensive for all but highly specialized applications where cost is no object. On the other hand, production of suitable fuel cells for industrial and general use at competitive prices should not be long delayed, with solar convertors already available.

The main point is that no one type of fuel cell will meet a 'universal' need and development must, of necessity, concentrate on producing the best type of fuel cell for a particular application or purpose. By 'best' is meant not only a fuel cell which is acceptable in cost but one which offers distinct advantages over the standard forms of battery it is intended to replace. There is no point in employing a fuel cell for industrial applications for its novelty value alone. At the other extreme, certain chemical processes may be adaptable to using the materials being processed as active fuels for a fuel cell system, whereby the necessary reaction is completed within the cell and electro-chemical energy extracted as a by product.

One must also not overlook that there are still possibilities relatively unexplored with 'conventional' cells. Most of the likely and possible combinations of electrodes and electrolytes have been tried, but despite claims from time to time for 'super batteries' which combine the high cell voltage of a lead-acid cell with the durability and high current performance of an alkaline accumulator none has evolved as a practical, commercial unit other than the combinations already mentioned as standard, and the mercury-cadmium sealed primary battery. The latter is a relatively costly unit to produce but has a particularly attractive performance for low voltage supplies—see Fig. 2—and can be produced from extreme miniature sizes upwards.

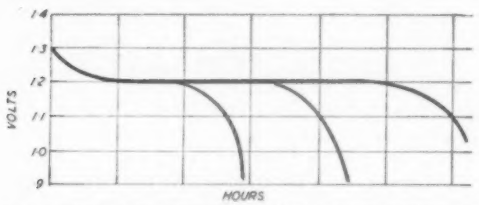


Fig. 2.—Typical discharge characteristics of Mallory mercury primary cell

Quite recently, too, the possibilities of the water-activated cell have come to the fore. Basically this is a primary cell where the electrodes are so chosen as to give a favourable 'battery' performance when wetted with a salt water solution (or a similar simple chemical solution). Once activated in this manner the cell has a limited life but during that period—which may range from ten to thirty minutes in the case of minite cells up to several hours—even a tiny cell is capable of producing a substantial current and maintaining a voltage of the order of 1·5 per cell. The specific advantages are the very small and light battery required for a given (limited duration) duty, coupled with the fact that the cell is completely inert until activated. Main disadvantages are cost and the fact that once activated the useful life is strictly limited whether or not the cell is used continuously. In the case of a tiny cell no bigger than a postage stamp and weighing only 1/50 oz in the dry state, for example, a 1·5 volt output into a load drawing up to one ampere gives a continuous supply for a matter of about one minute. Used for short periods only on such a load—e.g. 15-20 sec at a time—some five or six separate operations can be achieved within a period of about 25 min. In either case (run continuously or intermittently over the useable life period), the cell is of no more use at the end. It is essentially a primary battery which cannot be recharged. (Contrary to popular belief, Leclanché-type dry batteries *can* be recharged and in certain circumstances show a working life of up to thirty cycles, although this is rarely attempted or considered worthwhile).

Larger batteries of the salt-solution activated type are capable of more sustained output, and again with high current drains, if necessary. Actual performance will depend primarily on the choice of electrodes and activating solution, and on treatment of the positive electrode surface. Usual electrodes (for salt water activation) are a silver or silver chloride positive plate with a magnesium negative plate (commonly folded around the silver positive and separated from it by dry lint or similar absorbent material). Due to the high silver content by volume, the cost of production of such cells is high, but weight and bulk can be reduced to an almost unbelievable minimum. The outer 'casing' needs only to be a thin waterproof bag.

Water-activated batteries of this type have, obviously, a more limited application than standard cells, but can be ideal for emergency power use and similar duties where their complete freedom from deterioration until actually activated means that they can be ignored once fitted. They are already used as the standard power supply for such emergency equipment as the 'Sarah' beacon where the battery is activated by immersion in sea water; lightweight battery supplies for equipment carried by meteorological balloons; and a number of other specialized applications where the extremely light weight of the battery can be put to advantage (and perhaps where the weight or size of a more conventional battery of similar output might be prohibitive). Absolute minimum size and weight are characteristic features of this type of cell.

Excessive weight is, in fact, probably the main disadvantage of the lead-acid accumulator, although the high cell voltage still gives it a better energy-weight ratio than the other heavy-duty type accumulators (nickel-iron and nickel-cadmium). It is also interesting that although the type is something like one hundred years old and has been subject to detail design improvements throughout this period, its overall performance is still only about one half of what it could be. It compares most unfavourably with the silver electrode alkaline

Table II.—BATTERY PERFORMANCE

Battery	Type	Average volts per cell on loads	Approx. Energy Ratios	
			Watt-Hr/lb	Watt-Hr/(cu in).
Lead-acid	Car type	1·9	15·0	1·3
" "	Aviation	1·9	13·0	1·0
" "	Industrial	1·9	13·1	1·4
Nickel-iron	—	1·2	10·6	1·0
Nickel-cadmium	Standard	1·2	11·0	0·6
" "	Sintered	1·2	11·1	0·9
Silver-cadmium	Standard	1·06	75–100	3·0
Silver-zinc	Standard	1·2	50–75	2·5

type accumulators, for example, both as regards energy/weight and energy-volume ratios—see Table II. Although both these ratios have been improved, particularly within the last ten years, there have been no major developments in lead-acid accumulator design and almost all batteries of this type still employ, basically, Planté positive plates and Faure negative plates.

The overall performance of the battery, however, does depend primarily on the design, construction and manufacture of the plates, and the use of separators of optimum form and type. It is largely attention to such details that has resulted in small but definite improvements over the years, but no spectacular gains—this applying equally well to alkaline type accumulators and dry batteries. Battery systems are geared to such more or less standard performances and any major step forward, it appears, must wait on the further development of fuel cells and—later on again—the nuclear battery. The latter, however, is by no means an 'ultimate' in future thinking. At the present state of knowledge it appears that such a battery will have serious limitations in both energy/weight ratio and current characteristics—to say nothing of high initial cost.

Industrial Dryer

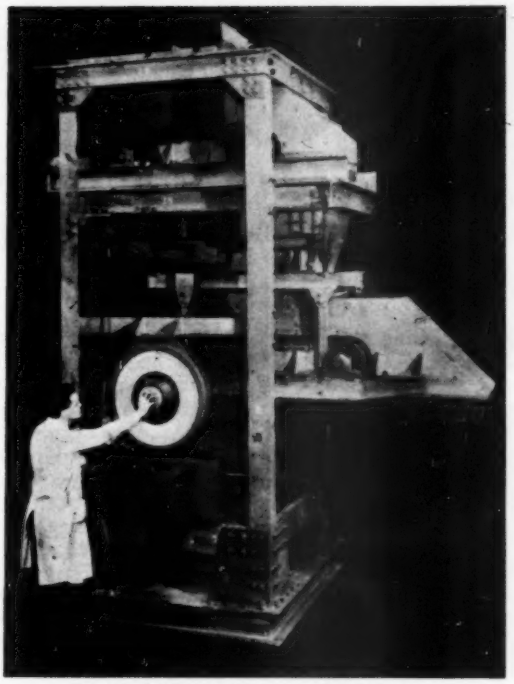
An industrial dryer of advanced design has been developed by Chemical Equipment Engineering Limited, Macclesfield. It can be tailor-made to suit the specific drying requirements of many industries including textiles and fibres, chemicals, pottery, foodstuffs, glass, plastics and metal parts. The C.E.E. dryer has a multi-sectional drying chamber, each section being fitted with an independent heater system, thermostat control and fan ventilator. This arrangement enables the dryer to deal simultaneously with different materials when each require different drying periods and temperature. The drying chamber is constructed from rigid non-metallic panelling which is non-corrodible—an important advantage when a corrosive atmosphere is produced during the drying operation.

Nylon Universal Joint

A ball type universal joint moulded throughout in nylon, impregnated with molybdenum disulphide has been introduced by W. M. Pollard, 'Half Acre', The Fairway, Oadby, Leicester. Injection moulded to precision limits, this 'Fairlon' joint consists of two identical end fork pieces and a central ball with two annular grooves at right angles. The fork pieces have plug holes in each end for attaching to the work piece. They are assembled instantly by snapping fork pieces over into the grooves in the central ball. The resilience of the nylon allows this. The joints are primarily intended for remote controls and light drives, but in a recent test two Fairlon joints of 1 in. dia were used successfully in an adjustable drill spindle to drill $\frac{1}{4}$ in. holes in mild steel at a deflexion of 30° at 900 rpm. The joints need no lubrication and wearing qualities are good owing to the low coefficient of friction of nylon.

Furnace Charging Equipment

The design and construction of a complete furnace charging system has recently been completed by Strachan and Henshaw Limited, the Bristol mechanical handling firm, to the order of Elektrokemisk A/S of Oslo, Norway. The equipment has been shipped to Tasmania, where it has been installed at the Bell Bay ferro alloy plant of Tasmanian Electro Metallurgical Company (Pty.) Limited.



Batch weighing unit for furnace charging system

The system comprises six batch weighing units—one of which is shown here—a belt conveyor, a circular bottom-discharge skip and a telpher hoist which can handle a gross load of 10 ton. The weighing units are placed under storage bins (two of which contain manganese ore, two coke, one dolomite or limestone and one slag) and deliver automatically weighed batches of raw materials on to the conveyor. This carries the complete charge to the skip for hoisting about 50 ft by a telpher, which then travels on a circular track to deliver the charge to the electric furnace at a number of alternative positions.

Electro-magnetic Flowmeter

An electro-magnetic flowmeter which is capable of measuring the flow of any liquid, slurry, paste or solid in suspension to an accuracy of $\pm$ 1% of instantaneous reading has been produced by Mawdsley's Limited, Dursley. The detector head of the "Emflux" has a moulded polyester resin fibre-glass casing which incorporates the terminal box. The amplifier is housed in a cast case and protected by a hinged glass door, fitted with a lock, for either wall or panel mounting. The detector head consists primarily of a length of pipe with standard flanges which can be inserted in the line where the flow is to be measured. The field coils round the pipe are supplied with alternating current producing a magnetic field across the working section of the pipe. Fluid flowing in the pipe cuts the lines of magnetic force and generates an emf at right angles to the axis of the pipe and the lines of magnetic force. This emf is directly proportional to the rate of flow, and is detected by two electrodes placed in the walls of the pipe diametrically opposite to each other and at right angles to the direction of the magnetic field. This signal is amplified and is used for indication, recording or control.

Production Practice:

Back Facing Tool
Self-contained Micro-adjusting Tool Head
Checking Bores of Small Batches
Quick Acting Clamp

By JOHN WALLER

BACK facing a component on a turret lathe is essentially a time wasting operation because it usually means another handling of the component with consequent resetting of the machine for what is a comparatively short cutting time, and though there are occasions—especially on short workpieces where a boss only requires facing on a casting and a short tool can project through the machined hole to complete the machining process—the great majority of workpieces need the second setting in order to finish them to length.

However, if conditions permit and this, of course, on many occasions rests with the number of parts being machined to justify the expenditure on special tooling, the design of a back facing tool is sometimes feasible if the bore diameter is large enough to allow a substantial bar to pass through, as such a bar is essential to house the tool required for the work in question. Fig. 1 illustrates a back facing tool bar with the tool in the withdrawn position to permit it to pass through the

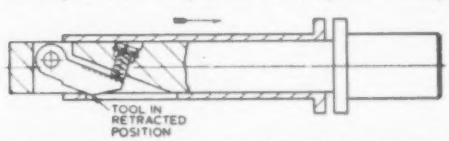


Fig. 1.—Back facing tool in the retracted position with left-hand part of groove in sleeve against the tool. The sleeve gives a swinging motion to the tool when it becomes necessary to swing it clear on the component bore

component without hindrance, and the sleeve A is used to turn the tool into the cutting position. The bar B is grooved to fit closely with the tool and a substantial pivot pin D holds it to the bar. Finally, a spring loaded plunger F is added to give the tool initial movement when it has passed through the component bore, and the length of this device depends largely on the amount the tool must move before the sleeve contacts the cutting edge and pulls it into the position depicted in Fig.2.

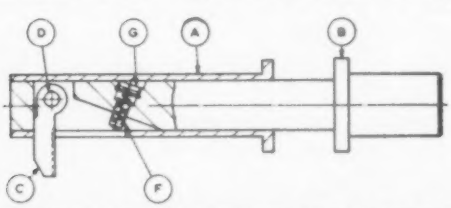


Fig. 2.—When the tool is in the facing position the back face is in contact with the rear of the slot in the tool bar. The pressure exerted while cutting keeps the tool vertical

To operate the tool, the sleeve A is moved to the left and this causes the right-hand edge of the slot machined in that item, to contact the tool and so push it down into the straight setting as shown in Fig. 2, and as the vertical face in the tool bar is arranged to contact the tool, the latter part remains at right angles to the component face during machining. On completion of the operation the sleeve is moved to the right and this causes the groove to contact the tool and forcibly push it back into the bar, thereby allowing the sleeve to be withdrawn together with the tool.

A disadvantage with a tool of this design is the presence of swarf in the groove after each operation and this, unfortunately cannot be prevented, but if the groove is made wide enough to allow the insertion of a brush, this will clean away much of the material and an application of an air hose should remove the remainder.

If necessary a bar of this design can have the usual pilot diameter on the left-hand end to locate in the bush of the turret lathe fixture, which adds to the efficiency of a long bar when it is removing material from what is often a rough surface and the cut is intermittent. Hardening the sleeve is advisable as it receives some abuse, particularly when the tool is retracted inside the holder, and as the latter continually rubs against the tool, the groove faces should also receive similar treatment to preserve the fit between the two parts and prolong the life of the equipment.

Tool adjustment in the boring bars used on the horizontal boring machine is generally limited to a socket headed grub screw immediately behind the tool to allow it to be pushed forward and so provide a varying degree of cut, and because of the simplicity of this method little or no provision is made for determining the actual amount of material removed as each setting is made; consequently this part of the operation is merely a matter of cut and try with the waste of much time.

To overcome this, especially as the bars in question were sufficiently massive to allow the incorporation of large tools, adjustable boring heads were provided and as these are easily replaceable when necessary, either to permit of quick substitution or to allow of tool grinding in a minimum of time, their apparently high cost was soon saved, and fine adjustments closer that 0·0005 in. obtained merely by rotating the headed screw at the rear of the tool.

The body A Fig. 3 consists of a piece of square steel bar which fits closely into a matching hole made in the boring bar, and the assembled head which appears here is simply held by the usual socket head screws fitted to the bar in exactly the same way as the boring tools are secured. The body is bored to receive the tool B and tapped at the rear end to receive the smaller thread of the adjusting screw C. A spring which performs the dual duties of clicker and also when needed acting as a pointer, completes the assembly, and though the number of divisions can vary according to the type of work being undertaken, those on the tool head in question were

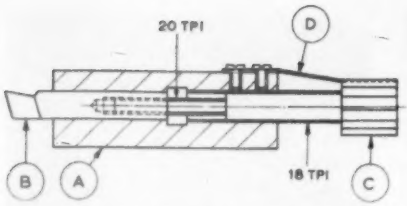


Fig. 3.—A few of these micro-adjusting heads is a useful addition to the horizontal borer tool kit. They can be interchangeable with several bars or are extracted for regrinding and replaced

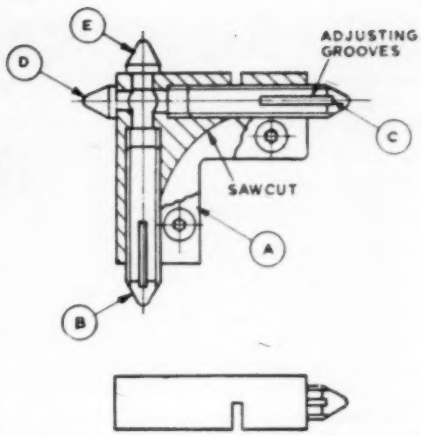


Fig. 4.—Adjustable inside gauge for use on small batches of products. It is light and easily handled

provided with eleven grooves, V-shaped as this number gave the following conditions:

A single revolution of the 18 t.p.i. screw, advances it a distance of 0·0555 in. and as this screw is directly connected to the 20 t.p.i. member, this portion also rotates one revolution but draws the tool back a distance equal to 0·05 in. Thus the tool actually advances a distance of 0·0055 in. and as eleven 'clicks' are provided each section of the head represe nts,0·0055/11 = 0·0005 in.

This figure is slightly in error due to the decimal approximation of the pitch of the threads but for practical purposes—in actual fact the error is only 0·005 in. in ten revolutions of the headed screw—it ensures that an operator can bore any hole with the closest of tolerances without difficulty. Tipped tools are preferable as the degree of tool wear with high speed tools is greater than the above mentioned error, and their use will enable the closest of tolerances to be observed for a long period without the need of resharpening when this is necessary, the head is withdrawn and replaced by another which has a properly ground tool and a fresh adjustment is made. Thus the grinding of the worn tool can be made at a convenient time when a long automatic feed is in progress. The groove machined in the top of the head is necessary to prevent the grub screws holding it in the boring bar from causing damage and so making it difficult to remove without resorting to using a hammer. Any damage done to the bottom of this groove is of no consequence. The head is taken out by simply sliding it rearwards.

A frequent problem when very small batches have to be produced of components with bores having a range of odd dimensions is the provision of a gauge for checking the bores. The use of the vernier is well known, but unless in sympathetic hands it can suffer damage. The inside caliper gauge is not so well known as the external type which is pre-set by the setter and applied over the various turned diameters, but it is ideal where it can be offered to a component having tolerances in the region of $\pm$ 0·001 in. A piece of steel bar A Fig. 4 is machined to an L shape and a saw cut is made partially to break into the tapped holes which house the screws B and C, and by using headed screws to close the gap, the latter hold the threaded anvils securely. Two fixed anvils D and E are arranged opposite the screwed members.

The setting of B and C is accomplished by a special key which engages with the grooves milled longitudinally through each screw, and both the 'Go' and 'No Go' are made with a micrometer, followed by the locking of the headed screws. The threaded anvils, in addition to the fixed details, require hardening because wear will naturally occur on the points, and also the grooves used for adjustment will become damaged through repeated usage.

While a gauge of this design cannot compete with the orthodox plug gauge, it nevertheless fills a gap and overcomes the use of such an expensive instrument as the vernier. Once a range of different sizes has been acquired a setting for any bore dimension is easily and quickly arranged, leaving a final check with the vernier to be made by the inspector.

Clamp design is frequently a decisive feature in fixture construction particularly when the operation requires the passage of milling cutters across the workpiece, when the setting of a clamp too high means that the cutter diameters are excessive, resulting in a greater tool cost and a slower working speed for the tools as they pass across a workpiece. Further, any clamping device which is quick operating is worth while incorporating in a fixture because of the time saved over a period, especially when several clamps require tightening after they have been moved into position.

The example depicted in Fig. 5 shows a clamp which combines low overhead clearance and rapid removal when the cutters have completed their work.

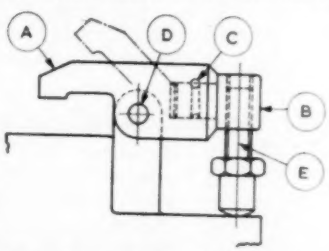


Fig. 5.—Swing clamp with no overhead projections

The clamp A fits between two lugs machined on the fixture base and is pivoted about the pin D, pressure being derived from the heel stud E. Pivoting heel H is attached to the main body and retained by cross pin C which allows the heel to rotate and at the same time keeps it in position. The action of releasing a component from the fixture thus requires only a slight loosening of the stud E and swinging it at right angles, when the clamp can assume the angle shown by the chain dotted outline.

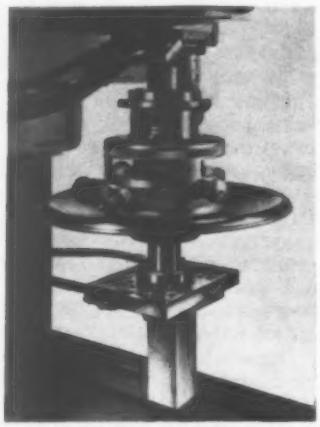
While the saving in clamping time is valuable, the reduction of the overhead clearance by the removal of a projecting nut is equally important as it permits the spacing collars used in holding a gang of cutters to pass within approximately $\frac{1}{8}$ in. of the top surface of a series of these clamps. Again, the ample clearance ensures a speedy and thorough cleaning of a location face, and when reloading, the parts are inserted in the fixture without difficulty as there is little risk of interference. If conditions allow, the substitution of a tommy bar in the pivoting heel in place of the hexagon is worth consideration.

Machine Tool Record

Spark Machining

A device evolved by M. Maillet, technical director of La Soudure Electrique Languepin in Paris, is the Seleromat spark machining boring and profiling head for use with the Seleromat A and B machines. It will be made available in the United Kingdom and throughout the Commonwealth by Solar Weld Languepin Limited of Burnley, Lancs. Primary advantages of the new head are that all electrodes for a given job can be the same size, machining speed is increased by up to 30%, and polishing time is reduced by 60-80%.

The new device consists essentially of a mechanism attached beneath the normal servohead of the Seleromat machine and to which, in turn, the electrode-carrier is attached. The servohead shaft does not rotate but simply moves axially to maintain the requisite spark gap. The boring and profiling head, however, imposes a horizontal orbital movement on the electrode carrier such that any one point on the electrode describes a circle in the horizontal plane. The rate of movement is of the order of 3½ orbits per min. Thus the gap is at the required minimum for sparking only at one relative workpiece/electrode position at any given instant of time. Around the whole of the remaining periphery the gap is wider. The wider gap at non-sparking positions allows a greater flushing flow of the dielectric and enhanced clearing of erosion debris.



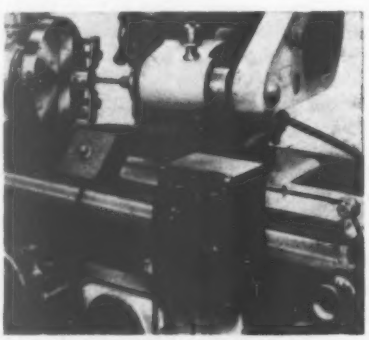
Detail of the new boring and profiling head showing body casing with cross-slide coupling and centralizing springs, locking plungers and comparators. Beneath the body is the circular splash-guard, the electrode carrier shaft, the carrier itself and the electrode

The orbiting motion produces a finer surface finish, enabling 0.2–0.3 microns to be obtained.

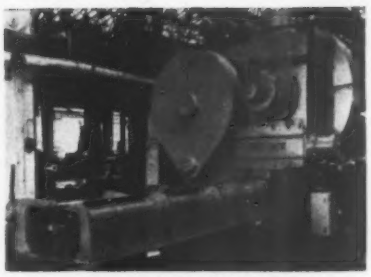
Grinding Wheel Touch Indicator

An instrument which comprises an accelerometer connected by a screened lead to a combined transistor amplifier and indicator lamp supplied with current from the electrical mains, the purpose of which is to indicate by visual means the moment the grinding wheel touches the workpiece, has been introduced by Coventry Gauge & Tool Company Limited, Coventry. Indication on this new Matrix instrument is displayed by a lamp on the amplifier or alternatively an indicator lamp on an extension lead may be attached to the machine at any convenient position. The instrument can therefore be used as a portable unit or the amplifier can be permanently attached to the machine in an unobtrusive position such as the control panel.

The instrument operates by accepting only the high frequency vibrations produced by contact of the work and wheel and using this signal to trigger a transistor switch thereby giving indication on a lamp. All the vibration frequencies on the machine are picked up by the accelerometer and fed into a filter network, where all the lower frequencies due to bearing noise, etc. are rejected. The instrument gives immediate indication of touch to an accuracy of five micro inches when used on a high precision grinding machine.



Matrix grinding wheel touch indicator



Lamberton No. 6 cold billet shear

Cold Billet Shear

A new cold billet shear for alloy steels—the No. 6—manufactured recently by Lamberton & Co. Limited, Coatbridge, is the largest so far of a range which has been developed specially to give clean, accurate cuts in alloy and mild steels. It will cut up to $7\frac{1}{2} \times 7\frac{1}{2}$ in. mild steel and to 6 in. × 6 in. alloy steel depending on quality. The stress relieved main frame is fabricated from heavy rolled steel plates into a single unit without the use of bolts to ensure rigidity. Accurate alignment of the moving blade is obtained by the long apron and guides on the main frame. Rigid clamping of the billet is achieved by a multi-wedge hold down operated by compressed air. Length of shear stroke is adjusted by handwheel and permits the stroke length to be limited to the minimum required to sever the billet; this ensures a clean cut, prevents double shearing and gives long blade life. Friction liners allow the flywheel to slip on overload. An electro-pneumatic control system governs the movements of the feed table, measuring stop and the action of the shear. These operations can be connected in automatic sequence or controlled individually by hand as required.

Rotating Centres

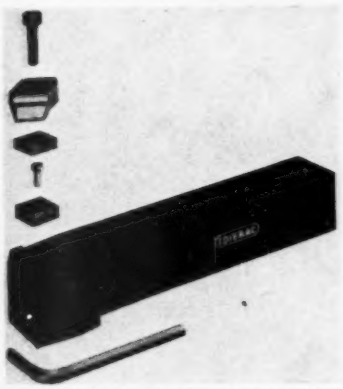
A new GMT rotating centre is announced by Gamet Products Limited of Colchester. The centres give a point concentricity of 0·0001 in. or better. The matched races and close machining tolerance ensure that friction, wobble and side play are minimized and the unit has been designed to provide maximum rigidity in all machining set-ups. Sizes are for 3, 4 and 5 MT and capacities range from 800 lb to 1750 lb at 100 rpm, and 190 lb to 420 lb load at 4000 rpm. Respective maximum speeds for the three sizes are 10,000, 9000 and 7000 rpm.

"Throw-away" Tip Tool

The latest development of the throw-away tip tool manufactured by Edibrac Limited, of Broadheath, Manchester, is the "Dualok", in which the tungsten carbide tip is held in position mechanically and not by brazing. The consequent freedom from brazing stesses enables the carbide to withstand the severest conditions and harder grades can be used with higher cutting rates to give increased production. Each tip has 3, 4, 6 or 8 cutting edges according to type and as each edge becomes worn the tip is turned to the next. When all the edges have been used the tip is thrown away, the tool remaining in the tool post ready for the insertion of the new tip. This eliminates the time spent on resetting and grinding and the need for special regrinding equipment. The setting of the solid carbide clamp/chip breaker is infinitely variable and can be adjusted to suit all materials and conditions. It is also reversible, is permanently rigid, allowing no deflexion and is highly wear resistant.

There is a standard range of left-hand and right-hand bar turning tools, facing tool and side cutting tools, all of which are available from stock in 1 in. sq and 1¼ in. sq sizes. Prices of holders are £3. 5s. 0d. and £3 19s. 6d. respectively. The Dualok can be supplied with either utility tips which are ground two sides or precision tips which are ground all over. The Dualok is available for positive or negative cutting.

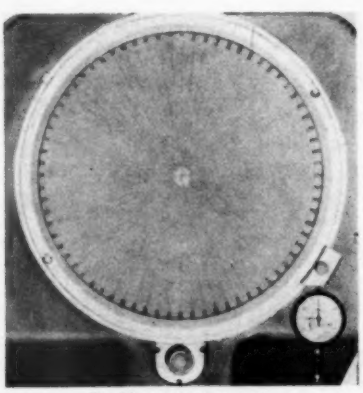
PROGRAMME DRILLING.—A new electronically-controlled version of the Meddings Pacera M8 turret drilling machine, for batch production of small components, has been developed by EMI Electronics Limited and W. J. Meddings Limited. This machine selects and positions any one or more of seven cutting tools in sequence, and drills the component completely automatically with considerable savings in time and cost. One operator can supervise several machines with even greater savings. The drill is fitted with an EMI-Grimston co-ordinate positioning table and an EMI control console and hydraulic drive. Numerical information coded on punched tape is converted into an electric signal to position the table, turret head and drilling station for a sequence of operations.



Dualok tool with clamped "throw-away" carbide tip

Precision Protractor

For use on their No. 600 reflex projector, J. E. Baty & Company Limited, Burgess Hill, Sussex, have introduced a precision protractor screen for which patent applications have been made. Fewer than usual main scale graduations are used and the finer readings are taken from the clear dial of a special dial indicator. The glass screen has accurately spaced and numbered lines at 5° intervals only and the dial indicator has a range of 5°. One revolution of the main hand of the indicator is equivalent to one degree and the main dial has 60 divisions. Therefore, degrees are read from the revolution counter dial and the minutes from the main dial. The glass screen is fitted into a ring which is a running fit in the normal rotatable screen ring of the projector. The two rings can be clamped together. The indicator contacts a specially formed abutment on the outer ring and can be made to propel the ring by turning a knurled sleeve connected to the indicator spindle.



Precision protractor screen

Woodworking Tool Grinding Machine

The well-known machine for grinding woodworking tools made by John Holroyd & Co. Ltd, Rochdale, Lancashire, has recently been re-designed mechanically and functionally, and has also been given a clean, modern appearance. The machine has two spindles, one carrying a coarse cup wheel for rough grinding and a fine oilstone for finishing, and the second a conical wheel, a high-speed emery wheel and a strapping wheel. The oilstone carries oil in a recess which percolates through to the surface. The machine will deal with all woodworking edge tools except saws.

Ball Bearing Die Sets.—A range of ball bearing precision die sets has been introduced by Desoutter Bros. Limited, The Hyde, London, NW9. Ball cages are of light alloy and the 5/32 in. balls are retained by a spinning process. Balls are spaced so that no two run on the same track.

New Kendex Tools.—The new Kendex Style KTCN-C tools provide a square nosed, positive rake tool for applications where standard style 230 brazed tools are now used. The new line utilizes standard triangular "throw away" inserts and chip breaker plates, provided in four shank sizes. Makers are Kennametal (Great Britain) Limited, 82 Coleshill Street, Birmingham 4.

Structural Use of Aluminium.—A new report on this subject issued by the Institution of Structural Engineers, 11 Upper Belgrave Street, London SW1, price 7/6, deals with the design and fabrication of aluminium structures and provides a basis for a contract specification.

EDGAR ALLEN LIME BURNING PLANT

This is a 180-ft rotary kiln producing 7 tons of burnt lime per hour in Israel. The burnt lime is used in cement manufacture and Edgar Allen & Co. Ltd. can also manufacture cement plants as complete "turnkey" jobs. The burnt lime can be hydrated for mortar or, on the other hand, used as a fertiliser. The Engineering Dept. of Edgar Allen also manufacture crushing and grinding machinery and ball mills to suit all applications.

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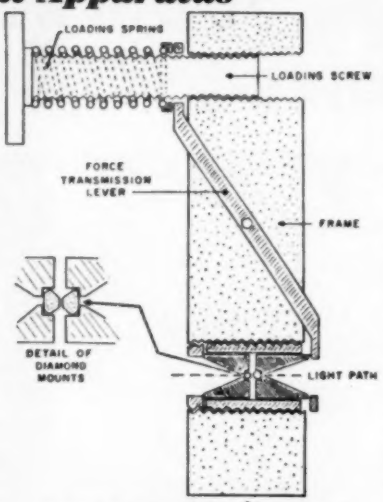
High-pressure Optical Apparatus

Direct visual observations of phase transitions and other changes occurring in transparent solids and liquids subjected to extremely high pressures are now being made at the U.S. National Bureau of Standards. To obtain these visual characterizations, Alvin Van Valkenburg of the Bureau Crystallography Section has coupled a tiny diamond pressure cell and a microscope which focuses through the diamond on to the specimen. Experiments at calculated pressures of 70 kilobars (1 million pounds) per square inch are being undertaken and observations at pressures up to 115 kilobars have been made. To obtain detailed information on the phases present at the various pressures, an X-ray diffraction camera which incorporates the diamond cell has been developed.

A study of the transitions that materials undergo at high pressures aids in defining interatomic forces and the perturbing effects of neighboring atoms on one another. By passing infra red and X-rays through the diamond pressure cell or viewing the transformations through a microscope it is possible to relate changes in crystal structures to changes in bond energies, force constants, and vibration frequencies.

The anvil-type diamond pressure cell contains two carefully ground diamonds, each having a diameter of about $\frac{1}{16}$ in. A specimen is placed between these two surfaces which are then squeezed together using a spring loading mechanism. This compresses the specimen into a film. Friction between the sample and diamond surfaces prevents the specimen from completely extruding. A polarized microscope with a 16 magnification objective having a long working distance is then focused through one diamond on to the surface of the specimen. Thus far, thallium halides, and halides of sodium, potassium and silver as well as a few other selected materials have been studied by this procedure.

Because the pressure at the centre of the diamond is greater than at the periphery, any transition is first observed as a point. With increased pressure this point spreads out into a ring. In cubic crystals, transitions



Schematic diagram of diamond "squeezer"

can be observed as an island emerging at the centre of the diamonds and then spreading out into a ring. The ring represents the boundary between the two polymorphic phases that have different indices of refraction.

Adapting the diamond pressure cell for X-ray diffraction studies, C. E. Weir and G. J. Piermarini, also of the Bureau Crystallography Section, have developed a high-pressure, X-ray diffraction powder camera. With this aparatus, X-ray beams, initiated from a molybdenum radiation source, are completely transmitted through the diamonds and the specimen. Diffraction rings from the compressed powdered specimen diverge through the diamond and are recorded on a film which is covered by a light-protective paper. The instrument is utilized in a routine manner at room temperature up to pressures of approximately 60 kilobars. Pressure is applied by a piston actuated by a hydraulic liquid and is measured with a bourdon-type gauge. A valve in the pipe line between the pump and the gauge enables the pressure cell and gauge to be isolated from the pump during exposures. The dimensions of the unit and the diamond surface areas are such that the hydraulic pressure is magnified by a factor of approximately 500, thus, to obtain a pressure of 60 kilobars on the specimen, a liquid pressure of approximately 2000 psi is required.

Making Welded Drums for Large Boilers

Two large boiler drums of the modern type having short stubs for attachment of the tubes, are being made at the Greenwich works of G. A. Harvey & Co. (London) Limited, to the design and order of Mitchell Engineering Limited for Komati Power Station in the Transvaal. Four similar drums were made by Harveys in 1960 for this same station.

Komati is a new power station some 160 miles from Johannesburg which will provide electricity for the national grid and is a link in a plan formulated by the Electricity Supply Commission of the Union of South Africa to build power stations near the sites of projected gold fields before work on the mines begins. Already two 100 MW boilers are in commission each capable of generating 900,000 lb steam/hour, with an overload of 990,000 lb. The contract for the building, installation and commissioning of drums, furnaces, super-heaters, economizers, soot blowers, air heaters, pulverized fuel firing equipment and auto-control is being carried out by the South African associate company of Mitchell Engineering Limited, Peterborough.

The new drums are for two steam generating units, each rated at 1,125,000 lb steam/hr but capable of 1,237,000 lb hour at peak load. They are designed for a steam pressure of 1,500 psi at 590° F, the boilers having a final steam outlet temperature of 965° F.

The drums are 47 ft. long with an inside diameter of 5 ft and a finished weight of 55 ton and made from Colvilles Ducol W.30 alloy steel plate $3\frac{1}{2}$ in. thick, the shell being fabricated from four belts of plating and the dished and flanged ends spun on Harvey's Rotarpress (one of only two such machines in Britain). In addition to the usual

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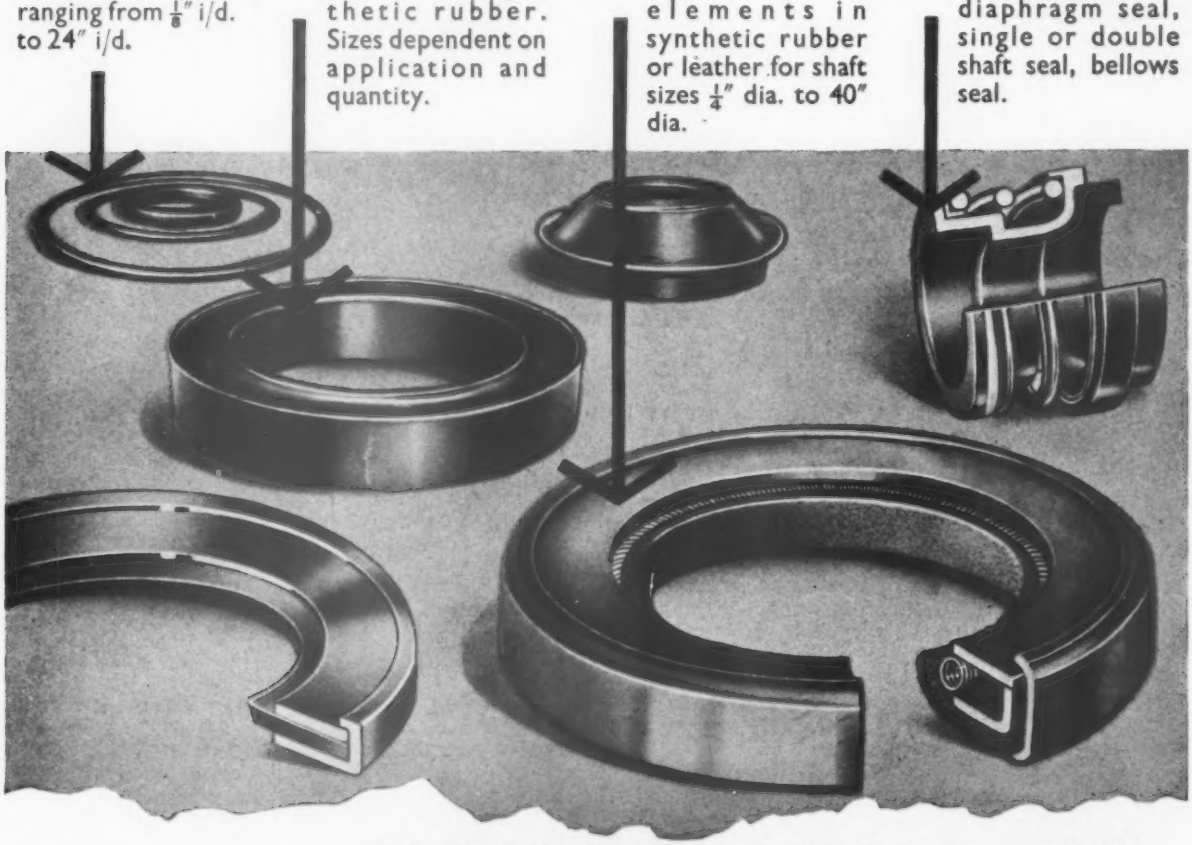

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Fig. 1.—Lowering a 3½ in. thick steel plate into a 3300 ton vertical bending press

Fig. 2.—Machining the longitudinal edges of two half sections of a belt

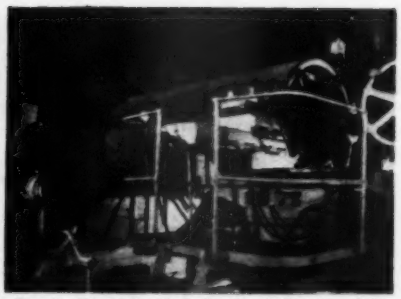


Fig. 3.—Machining the ends of a boiler drum belt

Fig. 4.—Preheating the longitudinal seams before welding

Fig. 5.—Welding steam downcomers to the shell

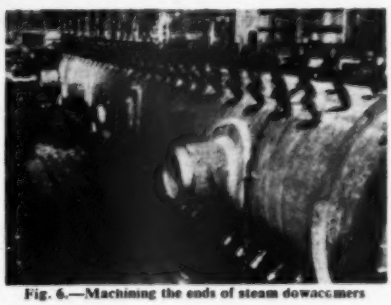


Fig. 6.—Machining the ends of steam downcomers

nozzles and standpipes, 438 stub tubes are welded to the shell, with ends prepared for welding on site to the boiler tubes. Each shell is also fitted with four 20 in. dia steam down-comers.

The shell plates were bent to form in a Fielding & Platt 3,300 ton vertical bending press and were prepared for butt welding of the longitudinal and circumferential seams with a double U-type edge preparation.

The welding of the main seams, for which the multi-run welding procedure was used, was carried out with a Fusarc 1,000-amp deck welder mounted on gantries with a Fusarc rectifier power source using Molymec grade continuous-feed electrodes of 6, 4 and 2 s.w.g. as necessary. Preheating at a controlled temperature was employed with inter-stage stress relief and radiographic examination. On completion the welded seams were ground flush and subjected to radiographic inspection by gamma ray.

The holes for the 438 stub tubes were drilled and machined for weld preparation for attaching the stub tubes and also to ensure that the stubs were fitted in the exact positions and welded without preliminary tacking to avoid root cracking of the stub tube welds.

Each drum has 350 stubs of 2¾ in. dia, 36 of 5¼ in. dia, and 52 of 5½ in. dia, and all were manually metal-arc welded to the drum using ESAB Unitrode electrodes of 8, 6 and 4 s.w.g. For welding the stub tubes, the drum was maintained at 100°C but Cooper Electroheat coiled elements, totalling 80 kW at mains voltage were inserted in the drum and mounted on a simple framework on wheels, the framework keeping to bottom dead centre and the drum rotating to permit entirely downhand welding of the stub tubes to the boiler shell. The outside of the drum was lagged to prevent heat loss.

The welding of the stub tubes was tested by the magnetic crack-detection and the completed drum was finally stress relieved at 650° C.

Both drums were subjected to a hydraulic test pressure of 2,250 psi and under the survey of the British Engine Boiler and Electrical Insurance Company.

For shipment to South Africa, the drums will be separately packed in steel cages for protection. This precaution proved invaluable when an earlier boiler drum overturned the railway wagon on which it was loaded, shortly after leaving Cape Town. Considerable damage to the stub tubes was prevented by the steel cage.

Air Bearings

Comparative cutting tests on a horizontal milling machine with its worktable fitted, in turn, with pressurized air bearings, pressurized oil bearings and a conventional lubrication system, show that the air-supported table is a feasible proposition and that the machine performance table is as good as with the conventional lubrication. The limiting factor on performance appeared to be stiffness of the over-arm and arbor and it is interesting to note that the *initial* stiffness of a fairly typical arbor and over-arm assembly can be as little as about one-thirtieth of that of an air-supported worktable. A feature of pressurized air bearings is the virtual elimination of both static and dynamic friction with consequent ease of positional control. Because there is no metal-to-metal contact wear is negligible and slideway accuracy should be maintained for a very long time. Another advantage is the cleanliness. Further information is given in: *NEL Report* No. 26 (The performance of hydrostatic slideway bearings in a milling machine, by C. A. Scoles) available from the National Engineering Laboratory, East Kilbride, Glasgow.

Eclipse hacksaw blades

"Daddy says they last longer"

Eclipse' hacksaw blades and other tools are made by James Neill & Co. (Sheffield) Ltd. and are obtainable from all tool distributors.

UH68

In Brief . . . .

Notes on New Materials, Plant and Machinery

Miniature Relay.—Continuing their policy of research and development B. & R. Relays, Harlow, have designed a miniature dry reed relay only 1 in. long and $\frac{11}{32}$ in. dia.

Photo-Electric Control.—A compact, low-cost photo-electric detector relay or counter, the Eglet, has been introduced by the Machine Automation Division of Elcontrol Limited, Hitchin.

Packaged Superheaters.—T. Sugden Limited, Manchester, are producing independently fired superheater packaged units which superheat steam at rates from 500 to 5000 lb/hr at temperatures of up to 1200° F. They are fired by light or medium oil from 35 to 200 sec Redwood 1 at 100° F. Control by outlet steam temperature is automatic.

Digital System.—A new digital system by which complex controls are assembled from basic standard units, is announced by Lancashire Dynamo Electronic Products Limited, Rugeley. The system is designed to ensure ease of understanding of even the most advanced installations.

Purpose Built Trucks.—A dropside truck supplied at short notice by WCB Containers Limited, Manchester, has a steel chassis and is panelled with moisture resistant phenolic resin coated plywood.

Banana Conveyor.—The new Banana discharging installation at Southampton employs the "Donald" patent elevator conveyor made by Rownson Conveyors Limited, Peterborough, and comprises a pair of endless parallel chains connected at intervals by crossbars upon which are mounted the loose canvas carrying slings.

'Triklone' Trichloroethylene.—I.C.I. trichloroethylene is now in only two standard grades for all normal industrial purposes. They are 'Triklone' A and 'Triklone' N.

Cleaning Oil-fired Boilers.—The British Vacuum Cleaner & Engineering Company Limited, Leatherhead, are producing portable vacuum plant specially for cleaning oil-fired boilers, sump emptying and floor drying.

Automatic Doors.—Equipment supplied by Tonks-Rowley Automatic Doors Limited opens and closes doors automatically by pneumatic, hydraulic or electric means from carpet control, push or pull switch or by the breaking of a photo-electric ray.

Polyurethane Foam.—The Baxenden Chemical Company Limited, London, are manufacturing polyurethane foam by a new frothing process from mixed chemicals pumped from the nozzle of the mixing machine as an already partly-expanded lightweight froth for introduction into moulds or cavities of any shape or size.

Fan Developments.—Three new developments in fans, of Woods of Colchester Limited, are a silencer for aerofoil axial flow fans, a bifurcated fan for saturated atmosphere and hot gases, and a new range of small aerofoil fans for cooling electronic equipment, etc.

Deep Hole Rock Drilling.—Holman Bros., Camborne, have a new hammer unit, the VR. 4, which can be used with the Holman vole drill or adapted for use with similar drill rigs and offers conspicuous reductions in drilling times and more economical use of explosives.

Electronic Pressure Transmitter.—Fielden Electronics Limited, Manchester have introduced an advanced pressure transmitter in ranges from 0-50 up to 0-12 000 psig with a d.c. signal of 0-15 mA unaffected by line resistance, supply voltage variations, ambient temperature variations, a.c. pick-up, etc.

Factory Floors.—Flexible PVC floor tiles by Semtex Limited, London, were laid in the IBM factory at Greenock two years ago, and since then many of the plant machines, weighing up to five tons, have been moved across it on small wheeled bogies. The flooring is still in excellent condition.

Electric Generators.—Two new Onan electric generating plants are being marketed by G. M. Power Plant Company Limited, Ipswich,—a 10 000-W and 15 000-W model designed as versatile sources of power.

Heating Panels.—Photronic Controls Limited, Leatherhead, now offer complete panels for all heating control applications.

Photo-Electric Unit.—A compact square-bodied housing for a photo-electric viewing head or light source has been introduced by the Machine Automation Division of Elcontrol Limited, Hitchin.

High Intensity Radiant Burners.—For high temperature applications, G. & R. Gilbert (Industrial) Limited, Hackbridge, have developed a new range of high intensity gas fired radiant panels with surface temperatures of up to 1000° C, designed for either high pressure towns gas, low pressure towns gas with fan air, premixed gas and air from an air/gas mixing machine, or for liquid petroleum gas.

Pipe Fittings.—Bonney Forge International, Irvine, Ayrshire, has been formed to manufacture and sell the Bonney range of forged steel pipe fittings Weldolets, Thredolets, Sockolets, Elbolets, Brazolets and Sweepolets.

Steam Generator Package.—The "Vaporex" made by the Wansom Company Limited, Borehamwood, is a compact steam generator made in two sizes producing 220 and 660 lb of steam. The machine takes up little floor space and the two sizes are priced at £745 and £985 respectively.

Petter Diesels.—A new range of diesel engines with improved power/weight ratio, reduced dimensions and improved fuel economy has been introduced by Petters Limited, Staines, Middlesex. Both air and water cooled models are included with outputs ranging from 5 to $11\frac{1}{4}$ hp per cylinder at 1000 to 2000 rpm.

Half-inch Drill.—Wolf Electric Tools Limited, Hanger Lane, London W5, have added two double-insulated $\frac{1}{2}$ in. portable drills to their range. They are unusually light for their power and the motor is shrouded in polyester resin and glass fibre.

Relief Valves.—Andrew Fraser & Co. Limited, 64 Vincent Square, London SW1, are making a new PR Mark 4 range of pilot operated relief and unloading valves for measures up to 6000 psi.

Measuring Thread Charts.—A new range of thread charts produced by Watson, Manasty & Co., Limited, Orleans House, Manor Road, Teddington, enable the operator to measure the effective diameter as well as the form. Charts are available for a wide selection of forms and metric sizes will be available later this year.

Piston Valve.—The Newman-Fluidal piston valve being made by Newman, Hender Limited under licence from the Bendix Corporation is actuated by pressure on the piston to give rapid on/off control.

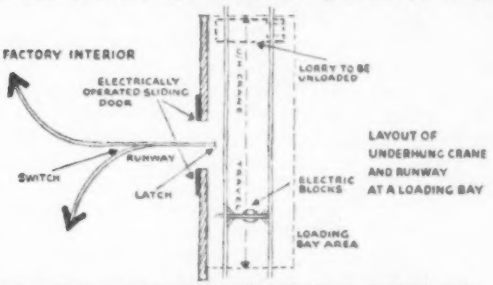
CUT HERE

Materials Handling-2

There are many types of crane, each having a particular application.

OVERHEAD CRANES

A crane should always be considered where loads have to be picked up, transported and put down anywhere in a fixed area. Overhead travelling cranes have three motions: longitudinal travel, cross travel and hoisting. These movements may be all manual, partly manual, partly electric drive or all electric drive. All-electric cranes are much more common; the smaller cranes which formerly had hand blocks for lifting are now generally fitted with electric pulley blocks. This has an added advantage with underhung cranes which 'latch up' to runways because the electric blocks can circulate around the runway system. Special-purpose cranes have been made with control gear incorporating



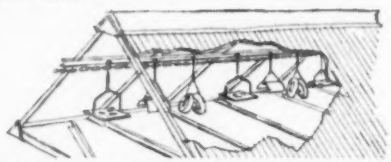
numerous modern electrical techniques, including inductor radio and closed-circuit television for remote control, and automatic control for process cranes with pre-set programming. Remote-control systems operated from ground level are being developed so that crane drivers do not have to be housed in bad atmospheric conditions up in a driver's cab on the crane. A safety control recently introduced is a crane-approach system employing high-frequency sonic equipment. The dangers of collisions between cranes and overrunning end-stops are eliminated, and complete protection can be given to maintenance men working on a disabled crane.

Other types are: fixed and portable jib cranes, portable stackers and mobile cranes.

CONVEYORS

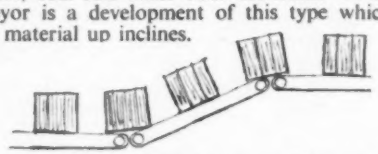
Conveyors are used when a continuous flow of articles has to be maintained between a number of points. The overhead chain conveyor does not take up any floor space, but can come down to a convenient height for loading and unloading. It provides a means of transport, a storage medium, and a method of carrying components through processes such as painting, storing and dipping.

With a pre-selective overhead chain it is possible to pre-select at any loading point one of the many discharge points for the material carried on it. The discharge may be effected either (*a*) by the material leaving the conveyor, or (*b*) by the respective conveyor trolley being switched on to a 'dead' or 'free' line, i.e., a siding. A further type of design allows the trolleys to stop at consecutive positions so that material can be handled through a series of production operations. All these types of conveyor can be built up as required into larger systems. They are amenable to electronic and punched tape, punched card or magnetic tape control.



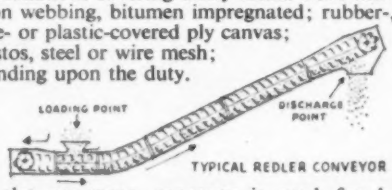
Drag-chain conveyors have a variety of uses in warehouses and factories for moving floor trucks, and may be of the overhead or floor type. The conveyor pulls the truck around the circuit to the required point, where it can be manually or automatically released, thus freeing a truck and allowing it to be pushed to one side.

Drag-link conveyors consist of a trough along which runs a chain buried in the material to be moved, such as swarf, coal and other bulk materials. A scraper conveyor is a development of this type which can move material up inclines.



Elevators can move material up or down a vertical or near vertical path. Some designs can also follow a horizontal path. An elevator usually consists of an endless chain, chains, or belt, to which flights, curved arms or buckets are attached, depending upon the type of load.

The belt conveyor is a common form of unit and is available in small units of from a foot or two in length to installations covering many miles. Belts can be of cotton webbing, bitumen impregnated; rubber-, neoprene- or plastic-covered ply canvas; asbestos, steel or wire mesh; depending upon the duty.



TYPICAL REDLER CONVEYOR

The slat or apron conveyor is used for heavier duties than the belt conveyor, one common design having roller chains fitted to each side of the slats with the chains running in side guides. Both slat and belt conveyors can be portable.

The screw conveyor can usually handle the following types of material: all finely powdered and granular materials, lumpy material—provided the lumps do not exceed about 2 in. in size—semi-liquid and fibrous materials.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. Telephone: TEMple Bar 9434.

Excellent reference books are available on electricity and productivity (8/6 each, or 9/- post free)—'Materials Handling in Industry' is an example.

E.D.A. also have available on free loan in the United Kingdom a series of films on the industrial uses of electricity including one on materials handling. Ask for a catalogue.

7924

Engineer Construction Plant. Military Engineering Vol. XVI. London, 1962: H.M. Stationery Office. 40/- net (by post 42/9). 805 pp. $6\frac{1}{2} \times 9\frac{5}{8}$ in.

Among the range of manuals prepared for the use of the Services there are many which, being readily available through H.M. Stationery Office, are of interest to and used by various sections of the public, and the book under notice is likely to become another of them, for having been written primarily for the instruction of officers of the Royal Engineers, and dealing as it does with a range of machinery which is also much used in industry, it will clearly be capable of serving a similar purpose in civil activities. It gives descriptions of the various types of machines and presents tabular data showing the main characteristics of typical examples, gives information on the capabilities and limitations of each item, and instruction on the planning, organization, and supervision of earth-throwing work. The categories of machinery covered include excavators, tractors, scrapers, graders, loaders, haulage equipment, compacting gear, rail stabilization plant, concreting machinery, tar and bitumen plant, pumps, compressors and tools, cranes, welders, trucks, conveyors, hoists, augers and saws. Two useful chapters, particularly in relation to the circumstances in which this kind of machinery is used, concern waterproofing, and work in cold climates.

Gas Film Lubrication. By W. A. Gross London, 1962: JohnWiley & Sons Limited. 105/- net (by post 106/4). 413 pp. $5\frac{3}{4} \times 9$ in.

The idea of using air or gas as a lubricating medium dates from a suggestion by Hirn in 1854. In 1897 Kingsbury made an air-lubricated journal bearing and Harrison, in 1913, evolved analytical treatment. Present-day interest dates from 1950, stimulated by high temperature missile and low-temperature cryogenic applications. Current use includes instruments, textile spindles, machine tools, dental drills, circulators, refrigerators and liquefiers.

After examining properties and dynamic conditions and discussing hydrodynamic equations, the author of this book investigates infinitely long steady self-acting films, finite steady self-acting films, steady externally pressurized bearings, and unsteady films and bearing systems; slider, journal and thrust bearings being considered in each case. The author offers a development of the fundamentals and their use in bearing configurations and the dynamics of bearing systems. There is a quite extensive literature on the subject in periodicals and proceedings, but this appears to be the only sizable book on the subject. It will certainly be of great interest to designers of advanced types of mechanism.

books

Fluid Film Bearings. By P. J. Geary. Chislehurst, 1962, British Scientific Instrument Association 25/- net (by post 25/7) 104 pp. $6 \times 9\frac{1}{2}$ in.

Instruments require nearly frictionless bearings and intensive development has proceeded in connection with gas and air lubricated bearings and hydrostatic (pumped) lubrication with liquids. These are surveyed in this monograph which is the fifth in a series on devices used in instruments. The principles of operation are explained and an extensive literature on design, behaviour and application is reviewed. There are also notes on squeeze films, the mercury globule bearing, and the acoustic radiation bearing.

Friction and Wear in Machinery. London, 1961; Pergamon Press Limited. 70/- net (by post 70/10). 263 pp. $5\frac{1}{2} \times 8\frac{1}{2}$ in.

This is a translation of Vol. 13 of a larger Russian work of the same title. It contains original studies by nine contributors covering wear resistance of carbon steels of different structures (A. A. Soroko-Novitskaia), the wear of metals in the presence of a non-renewable layer of abrasive (L. E. Val'dma), the wear of plungers and barrels of diesel fuel pumps (G. A. Tashkinov), the "mutual intrusion" of the surface layers of metals as a cause of wear during imperfect lubrication (L. V. Elin), the friction and wear of sleeve bearings with sulphuric acid lubrication (E. V. Lialin), the limiting plastic state in indenting and compressing a truncated cone (V. N. Marochkin-concerned with projections on bearing surfaces), a study of the position of the journal in a 120° fluid film bearing under constant and alternating loads (E. F. Zommer), pressure measurements in the oil film of a sleeve bearing (L. B. Khrisanova), and an account of an analytical and experimental investigation of the pressure produced in the oil film of a journal bearing with the axes of journal and bush skewed (L. B. Khrisanova). The volume concludes with an obituary notice of D. V. Konvisarov, an authority on the subject, and finally a bibliography compiled by E. O. Vil'dt.

The Mechanics of Metal Extrusion. By W. Johnson and H. Kudo. 1962: Manchester University Press. 42/- net (by post 43/-). $5\frac{1}{2} \times 8\frac{3}{4}$ in.

Though the extrusion process is much used now it is still better understood in practice than in theory. A lot of research has been done on it however, and the available results are useful in dealing with practical problems. As its title indicates, this book is concerned with the mechanics of the subject and not the metallurgy. It is in two parts, the first explaining the analytical and the second, the technological approach. The analytical work is concerned with idealized problems and before proceeding to the application of the theoretical results to industrial problems, the authors interpose an interesting chapter on the experimental verification of the theories. In the second part they examine three practical aspects and their effects—work hardening, complicated tool geometry, and working speed and temperature. These are finally summarized in relation to extrusion pressure, deformation, defects, and the properties of extruded products.

An Introduction to Refrigeration. By Norman C. Breddy. Richmond, 1962: Draughtsmen's and Allied Technicians Association. 5/- post free. 55 pp. $5\frac{1}{2} \times 8\frac{1}{4}$ in.

This pamphlet offers a useful concise introduction to a subject which is of increasing importance. The author covers the fundamentals and manages to include the necessary tabular data—and commendably so in the space available. He explains the basic cycles summarizes the thermodynamics of the subject, gives

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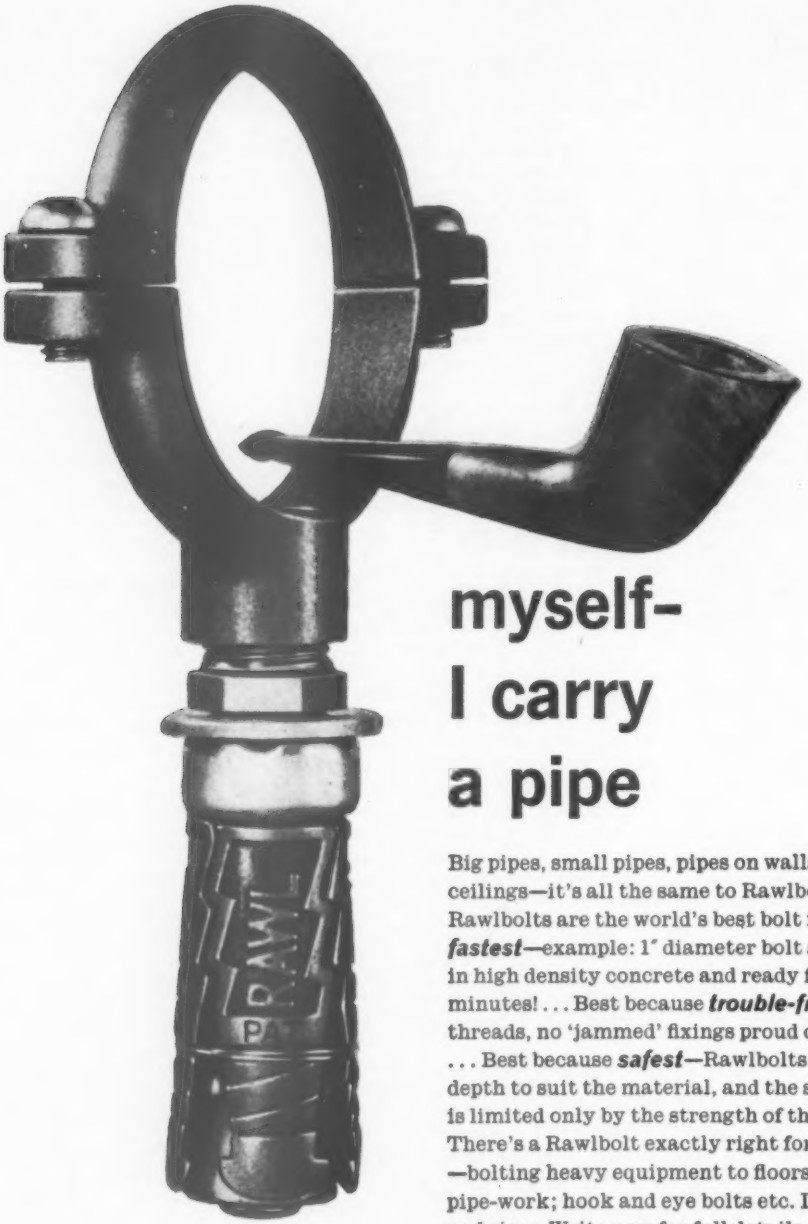

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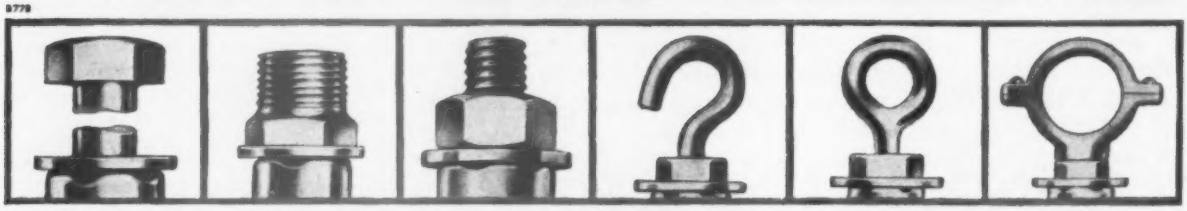

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the properties of the refrigerants, describes the absorption system, explains the principles and methods of psychrometrics and has something equally useful to say on low temperature refrigeration and on refrigeration controls.

An Introduction to Polythene Pipework. By R. Poynter. Richmond, 1962: Draughtsman's and Allied Technicians Association. 5/- post free. 44 pp. 5½ × 8¼ in.

Polythene is a versatile material having a high chemical resistance and is therefore useful in a good many plant applications, notably the pipework which is the subject of this pamphlet. It is made in a range of sizes, each suitable for a particular working pressure, all of which data are tabulated. Suitable joints have been evolved and these are described, also the technique to be employed in bending and fitting. The more recently introduced high density polythene is also given attention.

Solution of Problems in Fluid Mechanics. Part II. By John F. Douglas. London, 1962; Sir Isaac Pitman & Sons Limited. 21/- net by post 21/10). 205 pp. 5½ × 8½ in.

Students working for the B.Sc(Eng) degree and for the Higher National Certificate will find this book useful. It is rather more than the title indicates in that the author uses the worked examples to instruct the reader in the complete process of solution. The book is a second volume and deals with the more advanced parts of the syllabuses.

Elementary Kinematics of Mechanisms. By John R. Zimmerman. London, 1962: John Wiley & Sons Inc. 42/- net (by post 43/1). 290 pp. 6 × 9 in.

The elements of algebra and trigonometry and some facility in mechanical drawing are all that is required to pursue this text and to apply it in the analysis and design of mechanisms. Graphical as well as simple algebraic methods are explained. The subject matter includes velocity and acceleration analysis, linkages, cams, gears, and mechanism trains.

Stress-corrosion Cracking of Metals. By V. V. Romanov. Jerusalem 1961: Israel Program for Scientific Translations. 42/- net (by post 42/8). 151 pp. 6¾ × 9½ in.

When a metal under stress—particularly tension—also suffers from corrosion attack, then small cracks appear of a distinctive kind which lead progressively and often rapidly to failure. This is the kind of thing which constantly raises problems in chemical plant. The book under notice has been translated from the Russian and gives data from the author's own investigations as well as other sources, and deals with the mechanism of the general theory and the methods of investigating stress-corrosion.

Non-ferrous metals (melting and founding) regulations.—From January 30 next, those parts of factories in which workers are engaged in the melting and founding of non-ferrous metals will have to comply with The Non-ferrous Metals (Melting and Founding) Regulations 1962, S.I. No. 1667, (H.M.S.O. 8d. net) Floors must be cleaned once a day, all heavy equipment must be neatly stacked, gear and other tools must be stored away after use and loose materials, such as sand and fuel, must be kept in bins and bunkers. Proper gangways and pouring aisles free from obstruction must be provided, ventilating plant must be properly maintained and protective clothing provided and used. Other requirements come into effect on July 30, 1964, and relate to the construction of floors, the elimination, suppression and control of dust and fumes, the temperature of workrooms and the provision of washing facilities, clothing accommodation and facilities for meals. The Regulations do not apply to printing works, the smelting or manufacture of lead or solder, or any reducing operation.

Stoker's Manual.—Since the "New Stoker's Manual" was published by the National Industrial Fuel Efficiency Service in 1959, over 26,000 copies have been sold and a third edition has just been printed. The manual, an invaluable reference book for stokers and all those whose work is connected with the maintenance and operation of boiler plant, contains detailed information on the correct operation of hand-fired and mechanically-fired plant, the properties and use of different types of fuel, the requirements of the Clean Air Act, and many other chapters that assist operators to achieve efficient boiler house practice. It is produced in a handy pocket size for easy use on the job and can be obtained, price 3/- post free, from NFES Head Office, 71 Grosvenor Street, London, W1.

Oil Firing of Steam Boilers.—The Power Petroleum Company Limited have published a booklet "Oil Firing of Steam Boilers" which deals with grades and specifications of Fuel oils, the principles of combustion and the different types of oil burners available in this country. It also discusses combustion chambers and related equipment. A chapter is devoted to package boilers and a chapter to the correct method of storing and handling fuel oils. Copies are obtainable free from The Power Petroleum Company Limited, Cecil Chambers, 76/86 Strand, W.C.2 Tel: Temple Bar 3535.

Russian Periodicals.—Collet's 1963 Subscription Catalogue reveals that the number of newspapers and journals from the U.S.S.R. available to subscribers in the United Kingdom has again been greatly increased. Over 1,150 periodicals are listed, from children's magazines and Braille publications to highly specialised technical abstracts. The 324-page catalogue is available free from Collet's Subscription Import Department, 44/45, Museum Street, London, WC1.

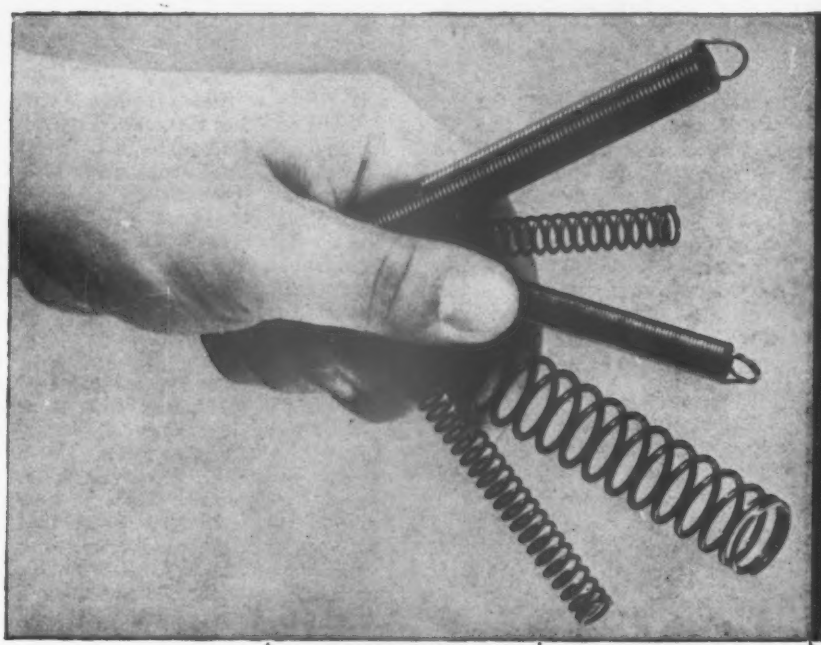
Welding and Cutting.—A revised booklet in the "Choice of Careers" series published by the Central Youth Employment Executive (H.M.S.O. price 1/3), gives all the details about prospects and opportunities for a career in this occupation that any would-be entrant needs to know. In some firms there are indentured apprenticeships for welders, usually for five years, beginning at the age of 16. In other firms some other type of approved learnership is the custom, and the starting age may be different.

New Standard

Flywheel housing mounting pads and brackets for I.C. engines (B.S. 3529:1962) Price 5/-

Part one of this standard specifies mounting pad face dimensions and pad location dimensions with respect to horizontal and vertical centre lines of vertical pads located above and below the flywheel horizontal centre line ('high' and 'low' pads). It also specifies diameters and location dimensions of tapped holes in these pads. Part two specifies certain dimensions of brackets which, when secured to the mounting pads dealt with in Part 1, form engine support arms.

British Standards Institution, 2 Park Street, London W1.



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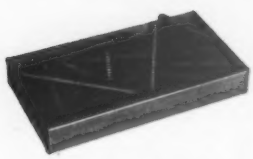

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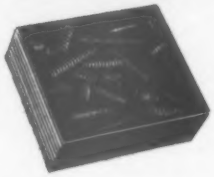

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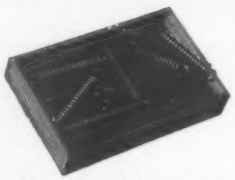

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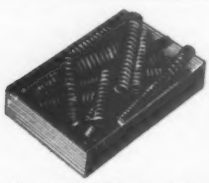

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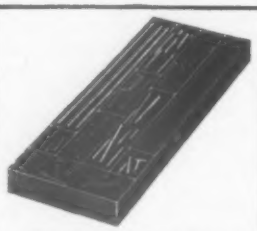

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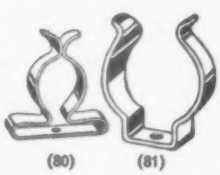

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BUSINESS & PROFESSIONAL

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THE ENGLISH ELECTRIC COMPANY LIMITED announces that **Lord Nelson of Stafford, M.Inst.C.E., M.I.Mech.E., M.I.E.E.,** who has been managing director since 1956, is now appointed chairman and chief executive of the company. **Mr. E. B. Banks, A.M.I.E.E.,** who has been deputy managing director since last April and **Mr. G. A. Riddell, C.A.,** who has been comptroller since 1954, are now appointed joint managing directors of the company. **Mr. John M. Stockland** has been appointed comptroller responsible to Mr. G. A. Riddell. **Dr. E. Eastwood, C.B.E. Ph.D., M.Sc., M.I.E.E.,** has been appointed group director of research. **Dr. F. P. Bowden, C.B.E., F.R.S., D.Sc., Sc.D.(Cantab)** has been appointed chairman of the group research council. **Mr. J. K. Brown, B.Sc., A.M.I.E.E.,** has been appointed adviser to the chairman of the company on long term product development of power equipment. **Dr. P. K. Watson** has been appointed company chief insulation engineer.

Mr. A. H. Roden has been appointed divisional manager of the transformer division of the Witton Works of the General Electric Company Limited. in succession to **Mr. F. J. Fisher,** who has relinquished his position on the grounds of ill health.

ASSOCIATED ELECTRICAL INDUSTRIES Limited announce that **Dr. J. C. Read, D.Sc., M.I.E.E.,** divisional consultant (Rectifiers) with the Heavy Plant Division has relinquished his position with AEI in order to become an independent consulting engineer. He has been 40 years with the company. **Mr. G. H. Moule,** formerly chief engineer of the heating and welding department will now manage the reorganized heating department and will be responsible to the general manager of the Transformer Division for the design, manufacture and sale of heating products made at Trafford Park and Rugby. *Motor & Control Gear Division:* **Mr. J. E. Herrin, A.M.I.E.E.,** has been appointed assistant manager, industrial machines department, Manchester. **Mr. J. A. S. Hilditch, B.Sc., A.M.I.E.E.,** has been appointed staff manager (Engineering) for AEI (Rugby) Limited.

THOS. W. WARD LIMITED, Albion Works, Sheffield, announce changes in the directorate of three companies in the Ward group. **Mr. Stanley J. Dyal** has resigned from the boards of Dick's Asbestos & Insulating Company Limited, and Anchor Insulating Company Limited, and **Mr. G. S. Wood** and **Mr. E. Wolstenholme** have been appointed directors. Mr. E. Wolstenholme also becomes a director of Frank Parker & Co. Limited, together with the present general manager **Mr. S. Lake.**

TECALEMIT LIMITED, announce changes in senior management. **Mr. P. R. Scutt** has retired as managing director of Tecalemit Limited and Tecalemit (Engineering) Limited and is appointed deputy chairman of Tecalemit Limited and chairman of Tecalemit (Engineering) Limited. **Mr. Nigel J. Bennett, D.F.C., F.C.A.** succeeds him as group managing director of Tecalemit limited and **Mr. J. E. Drinkwater** as managing director of Tecalemit (Engineering) Limited.

UNION CARBIDE LIMITED announce the following appointments due to the reorganization of the Alloys Division: **Mr. W. B. Whitworth** to be general sales manager for all Alloys Division products; **Mr. E. G. B. Trehearne B.Sc., A.I.M.** to be Sales Manager, Engineering Products; **Mr. C. Dunger A.I.M.** to be sales manager, ferro-alloys and allied products. **Mr. D. J. Crowe, M.A. (Cantab)., A.I.M.** to be manager of the newly formed technical service department.

ALFRED HERBERT LIMITED, Coventry announce that **Mr. J. C. Blair,** deputy chairman and **Mr. J. W. Ellson** who recently resigned from the board, retire from the service of the company on October 31. Mr. Blair has been associated with the company for nearly 50 years, and Mr. Ellson for over 43 years.

SAMUEL FOX AND COMPANY LIMITED, a subsidiary of the United Steel Companies Limited, announce that **Mr. W. F. G. Kerley,** manager of the watch spring department, becomes manager, watch spring and umbrella departments. **Mr. M. F. Stuart-King,** manager of the umbrella department joins the staff of the research engineer's department. **Mr. A. G. Briggs** becomes assistant manager, No. 1 melting shop. **Mr. J. D. Heys,** work study officer, becomes production controller. **Dr. O. J. W. Gilbert,** work study manager of the department of operational research, becomes manager, work study department. **Mr. R. Swinden,** works manager (services) has been appointed a director. **Mr. G. D. Illingworth** is works manager (personnel). He was formerly labour manager.

THE British Materials Handling Division of Yale & Towne, Wednesfield, Staffs., announce the appointment of **Dr. R. J. Tonks, B.Sc., A.M.I.Mech.E., D.I.C.,** as chief research and development engineer.

Obituary

WE regret to record the death of **Mr. Walter William Vinsen,** a director of the British Thomson-Houston Company, now AEI (Rugby) Limited, and director of manufacture until his retirement in December 1957.

WE regret to record the death of **Mr. A. H. Maggs, B.Sc.(Eng)Hons, A.M.I.E.E.,** Small Industrial Machine Engineering Department, AEI Birmingham Works.

Addresses

TECALEMIT Group headquarters will now be located at Old Court, Cox Green, Maidenhead, Berks., although established departments will continue at Plymouth.

METALOCK (BRITAIN) LIMITED, have opened a branch at Portsmouth in collaboration with Technivision Limited sales agents for Metalock in the Portsmouth area. The address is 67-69, Commercial Road, Portsmouth. Telephone-Portsmouth 24088.

THE WORCESTER VALVE COMPANY LIMITED, have moved to new premises at Burrel Road, Haywards Heath, Sussex, Tel. No: Haywards Heath 2740. Telex No: 8789.

BABCOCK & WILCOCK LIMITED have opened a new spare parts and service depot for Babcock-Weitz tower cranes at 68-74, High Street, Stratford, London, E.15.

FLEXELLO CASTORS AND WHEELS of Slough, Bucks, have opened a new office at Lombard House, Great Charles Street, Birmingham—Telephone Central 9382—under the direction of Mr. C. L. Trawford the area sales manager.

WALKER CROSWELLER & CO. LIMITED, Cheltenham have enlarged their London showrooms to house a separate demonstration area for the company's Arkon instrument division which includes a working demonstration of the Arkon effluent flow recording system. The showrooms are at 16, Great James Street, (off Theobald's Road.), W1.

MARTONAIR LIMITED pneumatic engineers, Parkshot, Richmond, Surrey, have opened a new office in the West country—at 19 Fairfax Court, Bristol 1. The telephone number is Bristol 292984. The manager is Mr. J. Kay.

MOBIL NORTH AND SOUTHEAST EUROPE Inc. has opened offices at 37/43 Sackville Street, London, W1.

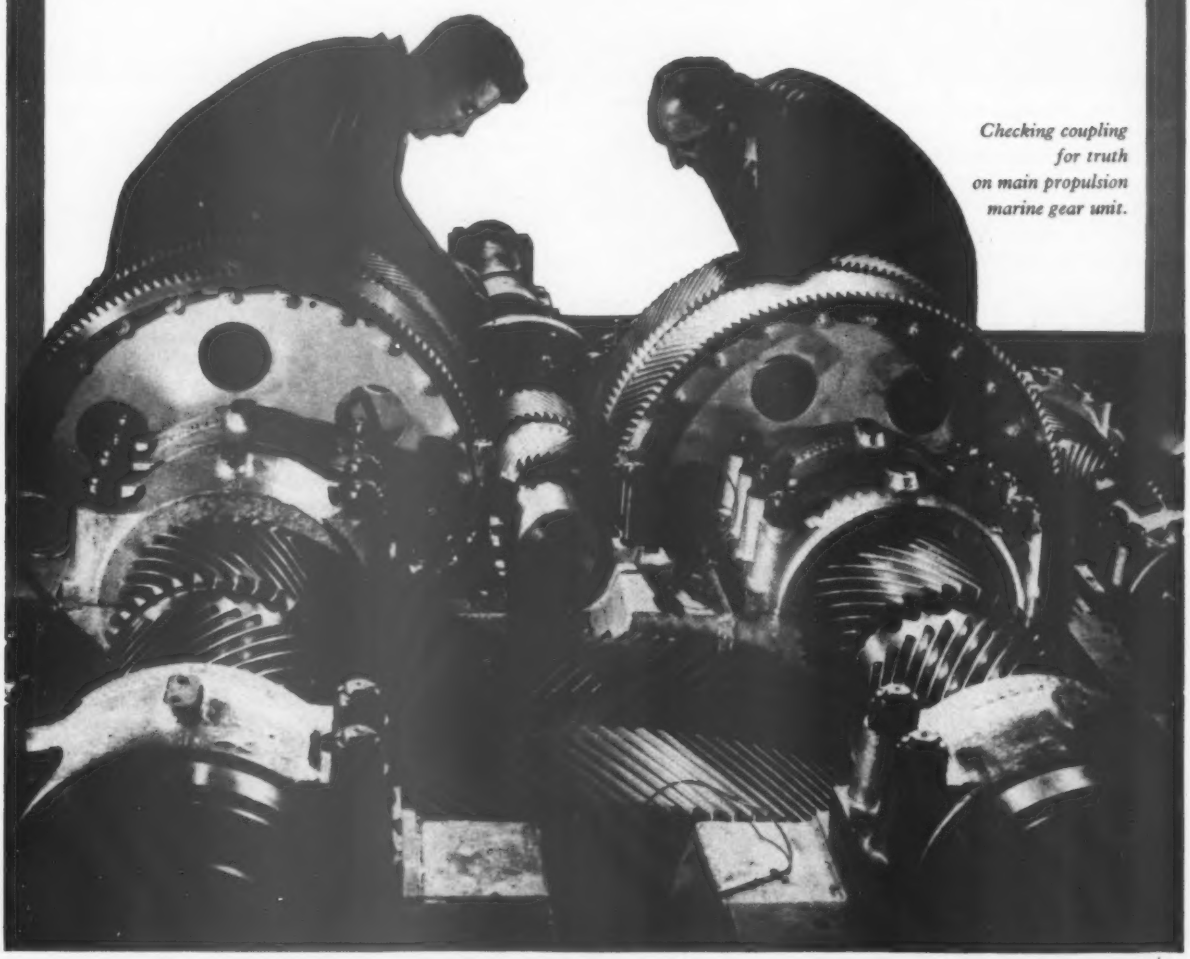
DU PONT COMPANY (United Kingdom) Limited. Plastics and Sales Development Departments are now located in new and large premises at North East Wing, Bush House, Aldwych, London WC2.

PERSPECTIVE ENGINEERING LIMITED, creative design, draughting and model making, a private company embodying a team of specialists formerly employed by the Advance Projects and Astronautics Groups

ACCURACY · RELIABILITY · QUIET RUNNING · LONG-LIFE

These are the product qualities that have put David Brown at the forefront of the world's gear manufacturers. These are the qualities that are accepted as being inherent in all

DAVID BROWN GEARS



Checking coupling for truth on main propulsion marine gear unit.

OA/6782

DAVID BROWN

An alliance of engineering specialists in gearing, machine tools, tools, castings, automobiles, and agricultural tractors and machinery.

THE DAVID BROWN CORPORATION (SALES) LIMITED

GEAR DIVISIONS · PARK WORKS · HUDDERSFIELD · TELEPHONE: 3500

of Hawker Siddeley Aviation Limited, has offices at 25/27, Oxford Street, London and studio facilities at Kingston-upon-Thames, Surrey.

ROBALLO ENGINEERING COMPANY LIMITED, the specialists in large diameter bearings, have moved to larger premises at 109, Jermyn Street, London, SW1.

A new British subsidiary, Hills-McCanna Limited, has been formed by Hills-McCanna Company, Illinois, U.S.A., manufacturers of ball valves, etc with headquarters at 23, Radford Crecsent, Billericay, Essex. Telephone Billericay 607/8. Telex 1982.

HESTON AIRCRAFT AND ASSOCIATED Engineers Limited announce that the company name has now been changed to HESTAIR Limited.

ALDER & MACKAY LIMITED, has now been integrated with U.G.I. (Meters) Limited. Northern Regional Works, Hermand Terrace, Edinburgh, 11.

KINNIS & BROWN LIMITED, 62, New Broad Street, London, EC2, Aqua-Clear water treatment and T. B. Bilton & Sons Limited, Bird Street, North Shields, Northumberland, Piping Installation engineers, have formed a new company for the Liverpool and Manchester areas, under the title T. B. Bilton & Sons (Liverpool) Limited, with offices at 27, Islington, Liverpool 3. (Tel. No. Liverpool NORth 0552).

Contracts and Work in Progress

ASSOCIATED ELECTRICAL INDUSTRIES Limited.—Order from the United States Atomic Energy Commission for an MS7 spark source mass spectrometer. Similar instruments have already been supplied by AEI to both the U.K. and the French Atomic Energy Authorities.

Contract, valued at over £60,000, for the supply of flue dust monitors to the Central Electricity Generating Board. *Heavy Plant Division*. Contract valued at over £200,000, for driving coal pulverising mills at the G.E.G.B.'s Tilbury 'B' Power Station. The order was placed on behalf of Foster Wheeler—John Brown Land Boilers Consortium. *Switchgear Division*.—Order worth more than £300,000 from the Central Electricity Generating Board for work on a grid substation in Lancashire. *Motor & Control Gear Division*.—Order worth £½ M for electrical control gear for nuclear power station at Oldbury.

Order worth about £300,000 from Distington Engineering Company Limited, Workington, Cumberland.

Electrical equipment ordered by Courtaulds Limited for a new textile plant being supplied to the U.S.S.R.

The Bristol Evening Post has placed an order on Electrical Drive Application Limited, for a new printing press drive designed and manufactured by AEI Motor Control and Gear Division, in conjunction with AEI Electronic Apparatus Division.

THE ENGLISH ELECTRIC COMPANY LIMITED.—Contract worth some £1,500,000 covering the supply of four 17,500 kilowatt gas turbine generating sets for the GEGB West Burton power station.

Order worth £1 M for four generators transformers for GEGB Ferrybridge 'C' power station.

EFCO FURNACES LIMITED.—Orders from Pakistan for heat treatment plant for hardening and tempering of steel shells.

HUMPHREYS & GLASGOW LIMITED.—Contract for the design and construction of I.C.I. continuous steam reforming plant at Effingham Street Gas Works, Sheffield, from the East Midlands Gas Board.

ORDER from North Thames Gas Board for four units of I.C.I. continuous steam reforming plant.

BRUSH ELECTRICAL ENGINEERING COMPANY Limited.—Orders from CEGB for seven 45 MVA and two 30 MVA transformers worth more than £400,000

THE NEW CONVEYOR COMPANY LIMITED, of Smethwick, Birmingham, (TI Group).—Contract worth over £¼ M for the supply and erection of a belt conveyor system to operate at a steelworks on the north west Arctic coat of Norway, for A/S Norsk Jernverk, Mo-I-Rana.

THE Loewy Engineering Company Limited of Bournemouth, (TI Group). Contract for a high-speed free forging press of 800 tons power for Jessop Saville Limited, Sheffield.

BROOKHIRST IGRANIC (Metal Industries Group) Sub contract from the Continuous Casting Company Limited of Weybridge for the supply of electrical controls for a new continuous casting plant to be installed by Western Canada Steel Company Limited at Vancouver.

Business Developments

Company Acquisitions

N. GREENING and Sons (woven wire manufacturers) has concluded negotiations for the acquisition of all the capital of The British Wedge Wire Company of Warrington.

I.M.P.A. LIMITED of Bury, Lancashire, manufacturers of plastic products, has become a subsidiary company of Turner and Brown Limited, plastic fabricators of Punch Street, Bolton. Both companies are members of Standard Industrial Holdings Limited.

Trading Agreements

GENERAL REFRACTORIES LIMITED have entered into collaboration with Sociedad General de Productos Ceramicos of Bilbao, Spain and have concluded a technical aid agreement for the manufacture of basic refractories.

YALE & TOWNE International Incorporated has concluded a long term lease for a manufacturing facility in the Halensee area of West Berlin.

Agents and Distributors

LIONEL HOOK & SONS LIMITED, of Elbey, Stroud, Glos., have appointed Aage H. Sejersen, export/import agents of Barrington, Illinois, U.S.A., sole distributors throughout the United States for their complete range of 'Cotswold' controlled dipping machines and accessories.

ASSOCIATED BRITISH MACHINE TOOL Makers Limited, 17 Grosvenor Gardens, London SW1 have been appointed the sole selling agents for AMT (B'ham) Limited, Bristol Road, Bournbrook, Birmingham 24.

NV STAALCONSTRUCTIE MONTAGEBOUW Demy, Geleen, Holland has been appointed to represent Qualter, Hall and Company Limited, mining equipment manufacturers of Barnsley, England, in Holland and Belgium.

BOYLES BROS. of South Gosforth, Newcastle-upon-Tyne, are now sole distributors through their associate companies Boyles Bros. (PTY) Johannesburg Limited, and Boyles Bros. (Rhodesia) Limited, Salisbury, for the sale of "Sehos" high pressure flexible pipes and fittings in Africa. Agreement between Boyles Bros and Singlehurst Equipment Limited

Film News

Tru-process Precision Castings.—This 16mm colour and sound film describes the production of castings manufactured in a large variety of materials by Darwins Limited, Tinsley, Sheffield 9. The film will be loaned to any company applying to the Publicity Manager at Darwins Limited.

Sintered Metal Techniques.—Dealing with the production of component parts by power metallurgy, this 16 mm. 22 min. colour film produced by Bound Brook Bearings Limited, Trent Valley Trading Estate, Lichfield, Staffs., will be distributed free on loan on application to Sound Services Limited, Film Projection Library Wilton Crescent, London SW19, or to The Rank Film Library, 1 Aintree Road, Perivale Greenford Midd.

Fluid Power Circuits—a Common-sense Approach. Made for the Department of Scientific and Industrial Research, this film introduces better practices in fluid power circuit design and construction. 16 mm., sound film in colour, 22 min. running time.

Optical Gratings and Machine Tools.—This is another film made for DSIR showing how optical gratings can be incorporated in machine tools particularly to obtain greater accuracy. Both films are loaned by The Central Film Library, Government Buildings, Bromyard Avenue, Acton, London W3. or by the Central Film Libraries at Glasgow and Cardiff.

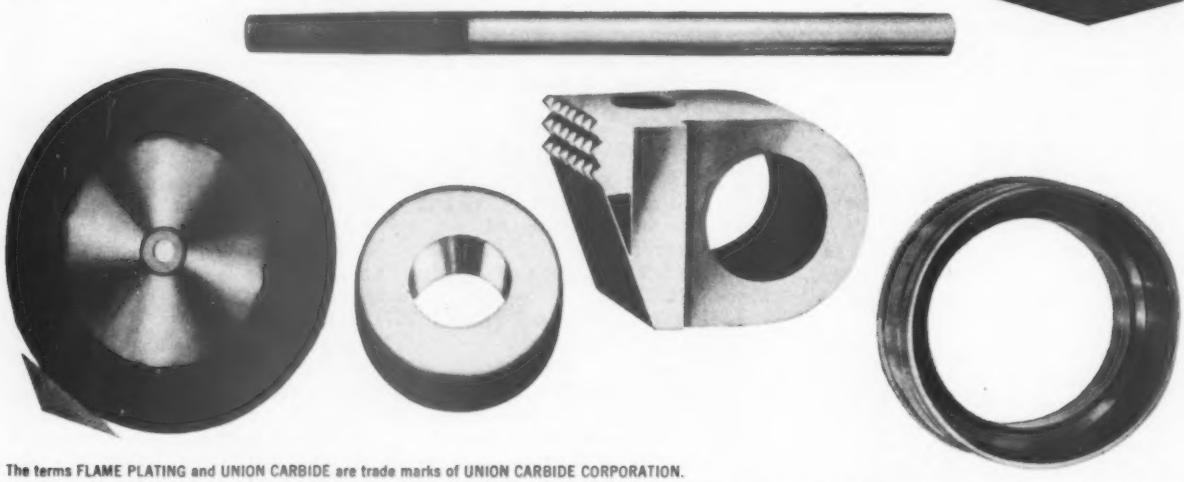
Flame Plating makes things harder for you!

The Union Carbide Flame Plating Process makes it possible to coat a thin skin of tungsten carbide on to any metal surface exposed to wear or abrasion.

Life increased up to 50 times! The process is particularly suitable for cutters, gauges, the wearing surfaces of industrial measuring tools, forming tools and working surfaces of textile manufacturing plant components. Tungsten carbide can be applied in this way to small or large areas and in thicknesses from .001 to .010 in. The coating can be renewed and costs considerably less than an insert of solid tungsten carbide. Flame plated components like gauges, core rods, drills and rubber skiving knives have their working life multiplied up to 50 times.

How is it done? In the Union Carbide Flame Plating Process, powdered tungsten carbide at a temperature of 3,300°C is 'fired' from a gun. Coatings of any thickness up to .010 in. can be applied by repeating the process. The temperature of the workpiece does not exceed 200°C in spite of the extremely high temperature of the plasticised carbide, thereby precluding any possible metallurgical change in the workpiece. If you are worried by wear in components that are costly to manufacture and renew, tell us your problem and we'll tell you if Flame Plating is the answer. In any case, send for our folder and read more about it.

UNION CARBIDE



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UNION CARBIDE LIMITED, Flame Plating Dept., Millers Road, Warwick. Tel: Warwick 41766. Head Office: 8 Grafton Street, London W.1. MAYfair 8100

CRC A76A

This specialised truck has a tilting platform which can be angled until flush with the floor. The load is drawn on to the platform by the Yale Pul-Lift anchored at the front end of the truck.

take time off WITH A YALE PLANT HANDLING TRUCK

One man and a Yale plant handling truck can shift machinery weighing up to 5 tons in a fraction of the time taken by more conventional methods. These rugged, versatile trucks come in capacities of 2, 3 and 5 tons. Write for illustrated brochure giving full details.

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REGISTERED TRADE MARK

World's largest range of materials handling equipment

The Yale & Town Manufacturing Co., British Materials Handling Division Dept. MW10, Wednesfield, Staffs. Phone: Willenhall 65511 Telex 33173

Magnetic Materials

Edgar Allen & Co. Limited, Imperial Steelworks, Sheffield 9, have been manufacturing magnetic materials since the early eighteen-nineties and have been responsible for notable pioneering work. Their present output in this class of manufacture includes magnetically hard materials or permanent magnets of any required shape; magnetically soft or high permeability materials and materials for special applications. Recently they have issued a 52-page illustrated technical booklet (Publication No. 153) which deals comprehensively with the whole subject—materials, manufacture and characteristics—which will be invaluable in enabling the user to design and specify magnets to suit his particular applications.

A further new publication (No. 125A) from Edgar Allen & Co. Limited is a guide to the company's products—crushing and grinding machinery and cement plant, magnets, steel castings, tools and tool steels, stainless and heat resisting steels, railway and tramway trackwork, mills, crusher, driers, heat exchangers etc.

Copy Milling and Turning

Several new illustrated publications from The Hepworth Iron Company (Engineering) Limited, Hazlehead, near Sheffield, give details of a number of interesting machines and pieces of equipment. They comprise an automatic scanning system for copy milling and hydraulic copying equipment for milling machines and lathes. There are different styles and sizes to suit duty and size of machine

Coolant Attachment

A device for supplying coolant to a cutting point which is portable and instantly transferable is illustrated in a leaflet from Haesler Sales, 4 Grange Street, St. Albans. It consists of a reservoir with foot control, flexible tube, and a nozzle on an adjustable magnetic stand. The tank holds one gallon and the accurately closed flow is controlled by slight foot pressure.

PVC Sheeting in Industry

An encyclopedia of the industrial end uses of unsupported PVC sheeting has been issued by Commercial Plastics (Sales) Limited, Berkeley Square House, Berkeley Square, London W1, manufacturers of Craylene and Fablon flexible, calendered, plasticized PVC sheeting. It describes and illustrates applications of these materials in, among others, the technical, industrial and engineering fields.

Rocol Molygear

The choice of the proper vehicle is always important in applying molybdenum disulphide for lubrication purposes, particularly with open gears, cams, pinions and all heavy, slow-moving plant where clearances are large and shock loads frequent. The molybdenum disulphide will reduce wear but a viscous and resilient basic lubricant is necessary to give cushioning and reduction of noise. Rocol Molygear is an ideal combination of these widely differing components and replaces the sticky viscous compounds previously used. It is clean and easy to apply and gives extended servicing periods and reduces maintenance costs. It has been developed in collaboration with leading manufacturers and users, and a selection of the reports received are included in a new leaflet obtainable from Rocol Limited, Rocol House, Swillington, Leeds.

Holroyd Thread Form

A new illustrated brochure from John Holroyd & Co. Limited, Rochdale, Lancashire, describes the feature of the thread form used on Holroyd worm gears, considered both from the performance and manufacturing points of view. Among the illustrations are some excellent sectional views.

Trade Literature

Readers interested in any of the catalogues reviewed here can obtain copies by mentioning* MECHANICAL WORLD *when writing to the firms concerned.

Conveyor Belting

A revised conveyor belting catalogue has been published by Turner Brothers Asbestos Company Limited, P.O. Box 40, Rochdale, and contains details of the more important developments in conveyor belt design which have resulted from the company's intensive research programme. In addition to providing complete details of the types and qualities of belting available, publication BA. 84 lays emphasis on the ever increasing importance of synthetic materials, and indicates how the properties of synthetic rubbers and fibres, can be utilized to select the right cover on the right carcase for all conveying duties.

"Poly-V" Drive

An A.4, 72 page "Poly-V" catalogue has been released by Turner Brothers Asbestos Company Limited, P.O. Box 4, Rochdale. Not only does this new publication contain complete information on drive design, service factors and horse-power rating on J, L, and M section belts but introduces also completely new comprehensive sections dealing with engineering data (7 pages), drive tables (24 pages) and flanged taper bush pulleys (11 pages). In the engineering data section, all aspects of Poly-V drives are covered under nine main heads, while the pulley section gives details of installation and removal instructions, bore and keyway dimensions as well as all standard flanged taper bush pulley sizes. Copies are available on request.

Lake Steamer

The current (No. 222) issue of "Crossley Chronicles," the house journal of Crossley Brothers Limited, Manchester 11, gives an illustrated description of the building of the R.M.S. Victoria at Kisumu for service on Lake Victoria. The ship was built by Yarrow & Co. Limited and shipped out to Africa in numbered parts for re-erection. The engines are a pair of Crossley HR Vee diesels developing 1700 bhp. A short history of the Lake marine service is also given.

Valves

Andrew Fraser & Co. Limited, 64-65 Vincent Square, London SW1. have released their new catalogue making available details of the new Fraser Series C, Mark 6 (piston type directional control valves) and the PR Mark 4 range (pilot operated relief and unloading valves.)

Steelworks Motors

A 6-page leaflet P1059 describing a range of new A.M. series a.c. steelworks motors is available from G.E.C. (Engineering) Limited, Witton, Birmingham. These robust motors for crane and auxiliary drives cover ratings from 7½ to 200 hp. Each motor is mechanically interchangeable with its A.I.S.E. d.c. counterpart.

Flowmeter

An electro-magnetic flowmeter for precise flow control or measurement in industrial or process plant is described in a new leaflet from Mawdsley's Limited, Dursley.

Rotoplunge Pumps

Now available from Parkinson Cowan Measurement, 7-17 Fitzalan Street, London SE11 is a new publication describing their Rotoplunge pumps Types U and V, the largest in the range and designed for use with liquids having some lubricating properties.

Telemetry

EMI telemetry equipment was originally developed to provide a guided missile telemetry system. A new brochure now available describes how similar equipment can be used in industry. It is particularly useful where it is necessary to control many units dispersed over long distances; or in plants whose sites extend over large areas. Copies can be obtained from EMI Electronics Limited, Hayes Middlesex.,

Power take-off

Leaflet, P.T.O. 102 from W. R. Anderton & Co. Limited, Rochdale illustrates a new range of power take-off equipment for Ford industrial diesel engines.

PRECISION MEASURING INSTRUMENTS

VERNIER CALIPER GAUGES

With fine adjustment to read 1/1000″ + 1/128″
Available between 8″–80″ lengths or in any reading to requirements

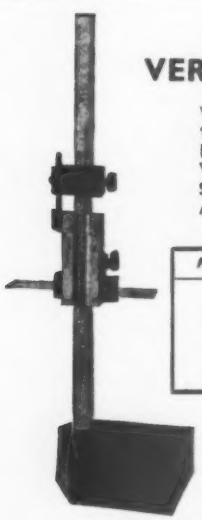
Now available in polished steel, stainless steel and chromed, front satin finished.

Model No.	Length	Bright	Stainless	Chrome
		£ s d	£ s d	£ s d
V.161 Without points	8″	3 10 6	5 19 0	5 9 6
V.165 Without points	12″	4 7 6	6 17 6	6 4 0
V.176 With points	12″	4 19 0	8 8 0	7 13 6
V.180 With points	20″	15 15 0	25 11 0	23 11 0

For direct reading of inside, outside and depth measurement. With quick-action cam-lock.

Graduated in 1/10 mm. + 1/128″ (V.22)
or „ 1/1000″ + 1/128″ (V.24)

Model No.	Length	Bright	Stainless
		£ s d	£ s d
V.22	5½″	2 12 6	3 6 0
V.24	6″	2 19 6	3 9 6



VERNIER HEIGHT GAUGES

With fine adjustment, to read 1/1000″
Beam graduated in 1/20″
Vernier graduated in 50 divisions,
Square Scriber.
Available up to 60″ reading

Model No.	Reading	Bright
		£ s d
H.230	12″	11 0 0
H.232	20″	22 0 0
H.235	36″	38 15 0

We are also importers of:

DEPTH GAUGES, PROTRACTORS, PRECISION TRAMMELS of various design.

Please ask for complete price list.

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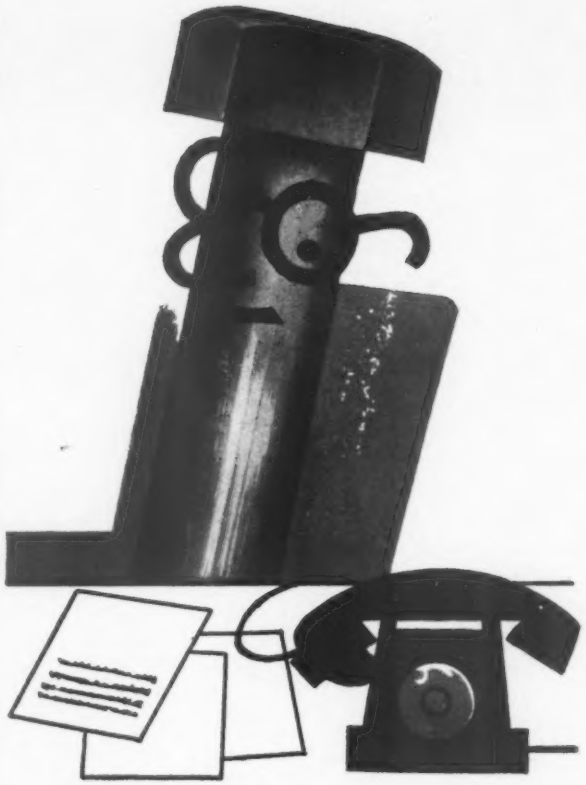

waiting for the phone to ring

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21

Blaydon (Co. Durham) Valley Plastic Coaters Limited. Factory additions. The builders are T. Clements and Son, Selborne Gardens, Newcastle-on-Tyne and the architects Wetherell, Lamb and Partners, 24 Picton Place, Newcastle-on-Tyne.

Bond and Company Limited. Plans approved for factory additions at Chainbridge Road. The architects are Wetherell, Lamb and Partners, 24 Picton Place, Newcastle-on-Tyne.

Blyth. Central Electricity Generating Board. Blyth "B" power station. The contract for the civil engineering work in connection with a coal reclaiming plant has been let to Sir R. McAlpine and Sons, Jesmond Road, Newcastle-on-Tyne.

Brandon (Co. Durham). J. Roston and Son, Paper Mills, Dennison Road, Selby, Yorkshire, propose offices etc. on the Langley Moor Industrial Estate.

Crook (Co. Durham). The Board of Trade are to build an "advance" factory at Crook. Contracts for the work will be allocated by the Industrial Estates Management Corporation, Team Valley trading estate, Gateshead.

Croxdale (Co. Durham). The North British Rubber Company Fountain Bridge, Edinburgh, are planning the erection of a factory at Croxdale to employ about 700 people.

Gateshead. Gibson Readymixed Concrete Limited, Haddricksmill Road, Gosforth, are to erect offices, laboratory and canteen at Saltmeadows Road, Gateshead. No contract let. The architects are R. Turley and Associates, 46 Jesmond Road, Newcastle-on-Tyne,

Matador Paper Mills Limited. The contractors for the rebuilding of a fire-destroyed factory on Team Valley trading trading estate are John Milne and Sons, Coatsworth Road. The architects are Page, Son and Hill, 75 King Street, South Shields.

Speedways Magnetos Limited, Leazes Park Road, Newcastle. Plans are being prepared by J. D. Coxon, 7 St. Mary's Place, Newcastle-on-Tyne, for single storey workshop and offices at Saltmeadows Road.

Newton Aycliffe (Co. Durham). The Expert Heat Treatment Company Limited, Garth Road, Lower Morden, Surrey, propose additions to their premises at Hilton Road, Newton Aycliffe.

Peterlee (Co. Durham). Peterlee Development Corporation, Shotton Hall, Castle Eden, are to build eight small factory units to attract new industries to the area. Tenders will shortly be obtained for constructing roads and sewers, and later, tenders will be sought for building the factories themselves. Plans are by the Corporation's chief engineer.

Acton. Acton Bolt Limited, are to extend their factory at Western Avenue.

P.B. Sillimanite Limited. The factory in Atlas Road is to be extended.

Birkenhead. Liverpool Patents Company Limited, Old Churchyard, Liverpool have submitted plans for a new factory at Hornby Street.

Birmingham. B.S.K. (Aluminium) Limited, Kenyon Street are to erect a new foundry and extend their existing works.

Bolton. Bush Beach & Segner Bayler Limited, Marlow House, Lloyds Avenue, London EC3. are to erect a new factory on Manchester Road industrial estate.

Brighouse. Lumb & Cornish (Fabrications) Limited, Leaches Yard, Huddersfield are to build a new factory at Armytage Road.

Chatham. The Rochester Welding & Engineering Company Limited, Bath Hard Lane, are to erect a new factory at Beacon Road.

Cheltenham. Micro & Precision Mouldings (Cheltenham) Limited, are to erect a new factory at Witcomb Place.

Crawley. Filmset Limited. The architects for the new factory at Fleming Way are T. P. Bennett & Son. 43 Bloomsbury Square, London, WC1.

Dagenham. Sonneborn & Rieck Limited, Extensions to the factory at Fowler Road, Hainhault industrial estate.

Dartford. Webb Conveyors & Automation Limited, 605 Princes Road. Extensions to factory.

Dewsbury. J. C. Oxley's Dyes & Chemicals Limited, Heckmondwike Road. Works extensions.

Doncaster. Bowser, Monks & Whitehouse Limited, Enterprise Works, Spring Gardens. New site at St. Sepulchre Gate industrial estate.

New Factories

Ealing. Churchill Instrument Company Limited, Walmgate Road, Perivale. Plans have been submitted for extensions to the machine shop.

Eastbourne. Armour Pharmaceutical Company Limited, Brampton Road. Plans have been submitted for extensions to the factory.

Enfield. Scripto Pens Limited, Lockfield Avenue are to extend their factory. The architects are Fuller, Hall & Foulsham, 212 High Holborn. London. WC1.

Hendon. Rawlplug Company Limited, Hale Lane, London NW7. Permission has been granted for works extensions.

London. Wallpaper Manufacturers Limited. The architect for the new factory at Wick Lane Works, Old Ford Road, E3 is R. Tubbs, 46 Queen Anne Street, London W1.

Margate. Allmetalwork Limited. A site at Westwood industrial estate is to be granted for the erection of a new factory.

Mansfield. J. B. S. Poyser (Engineers) Limited, Peek's Hill. Extensions are to be made to the works.

Penistone. Quayle Bros. Penistone Road, Sheffield. To erect a new factory on a site at Sheffield Road.

Whitby & Chandler Limited, Brunswick Road, Sheffield are to build a new works off Green Road.

Portsmouth. E. F. Moss & Co. Limited, Northern Parade, Hilsea, are to rebuild their factory at Dundas Lane industrial estate.

Rochdale. Robert Riley Limited. The Milkstone Spring Works are to be extended.

Rotherham. Slag Reduction Company Limited, Sheffield Road have submitted plans for the erection of a new factory at Meadowbank Road.

Skipton. Redman & Smith Limited. Permission has been received for extensions to Standard Mills, Cross Hills.

Smethwick. Tansey & Co. Limited, Oldbury Road are to build a new factory in Engine Street.

Surbiton. R. H. Windsor Limited, Leatherhead Road are to extend their factory.

Galleon Fireplaces Limited, Red Lion Road, Extensions to factory.

Tring. (Herts) William Batley & Co. Limited, Akeman Street. Approval has been granted for the erection of a new workshop.

Wakefield. F. E. Semper & Co. Limited, Westgate End. The architects for the new works are Simpson & Moxon, Southgate Chambers.

Watford. Mark Anthony Limited, are to make extensions to their Mapac Works, off Chalk Hill.

Wellington (Somerset.) Price Bros. & Co., Limited South Street. Factory extensions.

West Bromwich. A.1. Spring Company Limited, are to extend their works at Great Cambridge Street.

H. Richards & Son Limited, Kelvin Way. Works extensions.

Whitstable. Formex (G.B.) Grove Terrace, Highgate Road, London NW5. propose to erect a new factory at Millstrood Road.

Wigan. G. K. N. Reinforcements Limited, Canal Street. Permission has been given for extensions to works.

York. M. A. Craven & Sons, Limited, French Almond Works. Plans for a new factory at Low Poppleton Lane have been submitted.

Dalkeith. Norbury Instruments Limited of Newtongrange are to occupy a 12,000 sq ft factory at Mayfield near Dalkeith employing up to 1000 over the next three years. The firm will manufacture electrical and electronic equipment.

Dundee. Bonar Long and Company Limited, electrical engineers, are to add a 70,000 sq ft extension to their 350,000 sq ft space at Kingsway starting at an early date.

Glasgow. Charles Connell and Company Limited, Scotstoun who have already spent £1·5 million on modernization are to spend a further £175,000 on mechanical handling of steel plates, new machinery and a new workshop.

M. Macdonald and Son Limited, engineers, Millroad St., Calton, have been granted approval for the erection of workshop and offices at Drakemire Drive, Castlemilk.

Enfield-Standard Power Cables Limited have been given planning permission for a yard and shops at Oakbank St., Glasgow N.W.

Transport Development Group Limited have received planning permission for a three-block development at 24/30 Craigmount Street, Glasgow.

The Corporation Transport Department is to convert the Partick Tram depot to a major motor bus depot. A new depot is also being created at Fordneuk Street, Bridgeton.

Tartan Arrow Services Limited trunk line haulage contractors, are to erect warehousing, handling and vehicle depot at Milnbank Industrial Estate.

Grangemouth. British Hydrocarbon Chemicals Limited are to build at Bo'ness Road a chemical processing plant costing £130,000 and an ethylene storage tank at a cost of £2500.

Perth. J. Lyons and Company Limited, food manufacturers. New cold store and distribution depot at Newhouse Road, industrial estate at a cost of £25,000.

Shetland. Stephen Simpson Limited of Preston, manufacturers of gold and silver thread and insignia, are investigating location at Yell or Whalsay in the Shetlands to make use of the labour available there.

Tannochside, Lanarkshire. Caterpillar Tractor Company Limited are to erect an 84,000 sq ft £2 million extension to their factory established four years ago.

Maidenhead. Black & Decker Limited expect to start production at their new factory early next year. The Maidenhead factory, with existing plants, will give the company over 300,000 sq ft of floor space.

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1. **Mechanical Engineer—Ref. NR. 637/1159**

   Qualifications: Graduate or Corporate Membership of the Institution of Mechanical Engineers or eligibility for exemption from the Institution's examination for Graduate Membership. In addition, the candidate should have a minimum of two years' practical experience (post-graduate) in mechanical engineering and gained experience in the following: (a) Diesel and petrol engines (b) Heavy earthmoving and contractors plant (c) Workshop and Stores Organisation procedure (d) Drawing Office practice. Experience in waterworks pumping plant, refrigeration and air conditioning, electric motors, generators etc. and machine shop practice would be an advantage.

   Duties: Supervision and control of maintenance and repairs to all types of equipment including road plant, earthmoving plant, general contractors plant, waterworks installations, diesel and petrol vehicles etc.

   Salary: £1440—£2202 per annum gross, entry point depending on years of experience, plus £150 per annum gratuity. Free passages to and from Nigeria.

2. **Works Superintendent Mechanical (Refrigeration and Air Conditioning) Ref: NR. 646/1168.**

   Qualifications: Candidates must be fully conversant and experienced in the operation, maintenance and overhaul of the following: (a) Air conditioning equipment of both the window type units and larger capacity units for full installations of up to 10 H.P. and (b) Refrigeration equipment including all types of domestic refrigerators and larger refrigeration equipment of up to 10 H.P. as applied to cold rooms etc. Preference will be given to candidates who possess a City & Guilds Certificate in refrigeration and air conditioning.

   Duties: The supervision of maintenance and overhaul of all refrigeration and air conditioning equipment owned and operated by the Government of Northern Nigeria. Candidates would be expected to give theoretical and practical instruction to prospective indigenous tradesmen and plant operators in refrigeration and air conditioning.
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THE proprietor of British Patent No. 777885, entitled "Plug Valve" offers same for license or otherwise to ensure practical working in Great Britain. Inquiries to Singer, Stern & Carlberg, 140 So. Dearborn Street, Chicago 3, Illinois, U.S.A.

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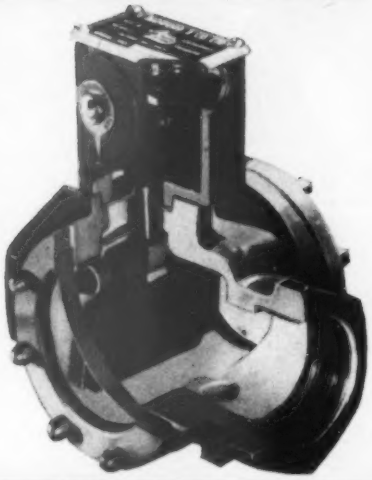

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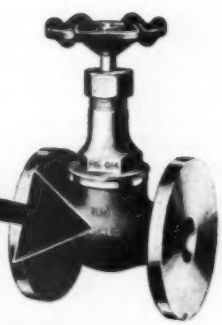

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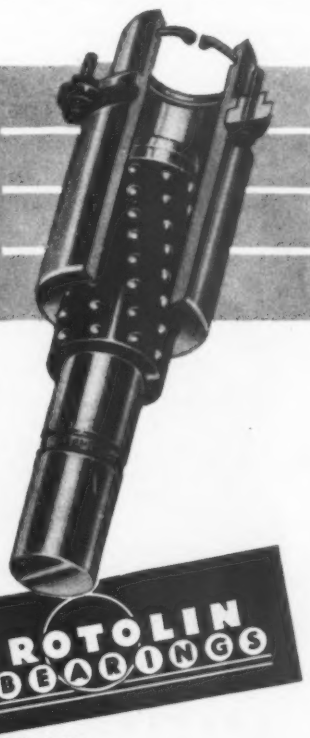

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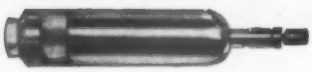

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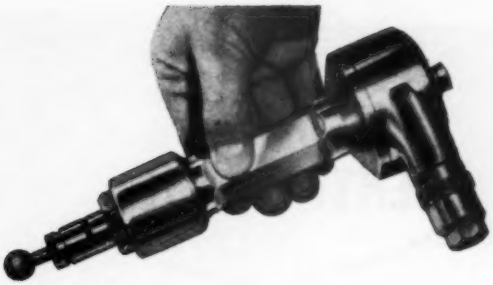

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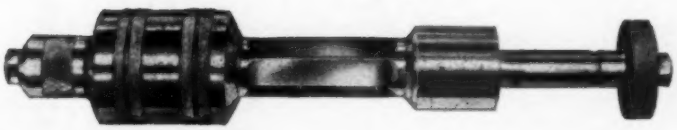

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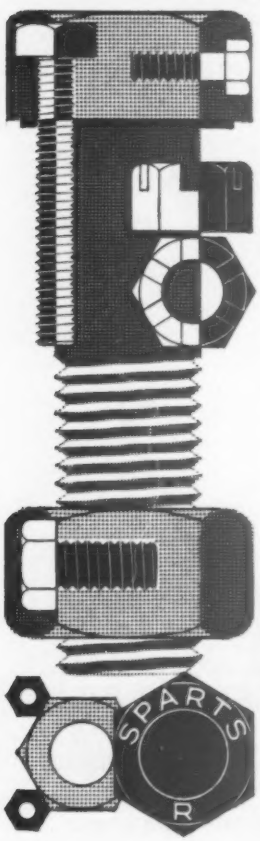

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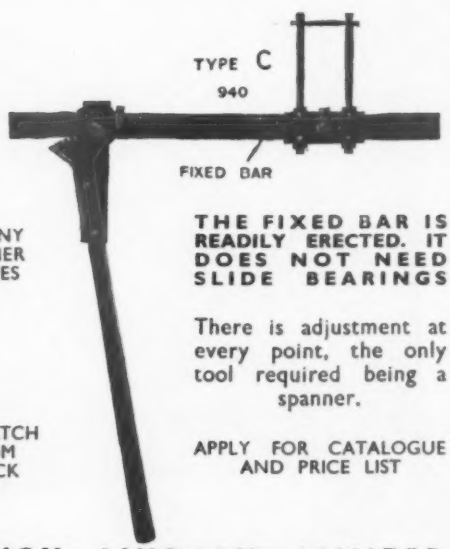

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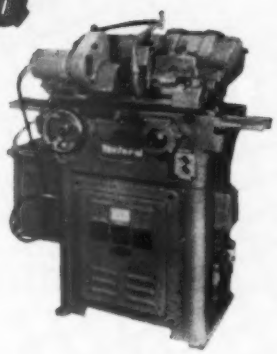

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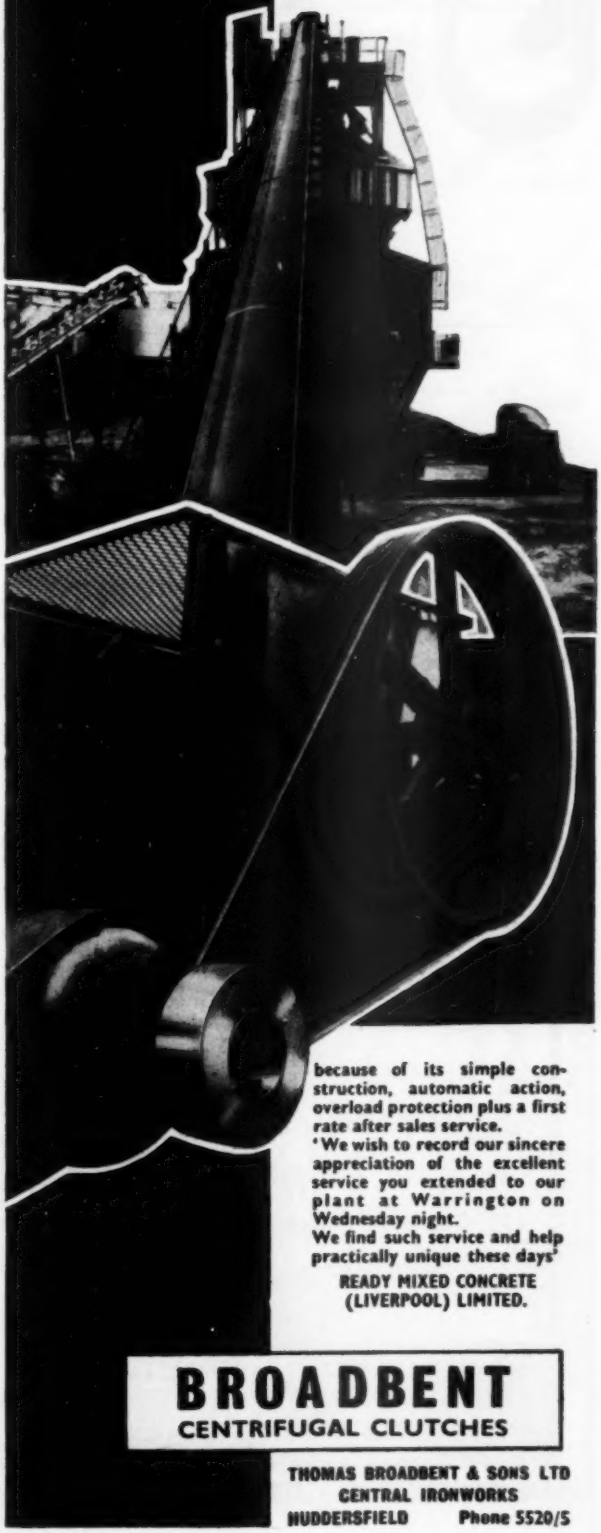

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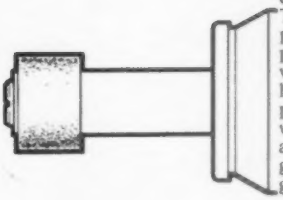

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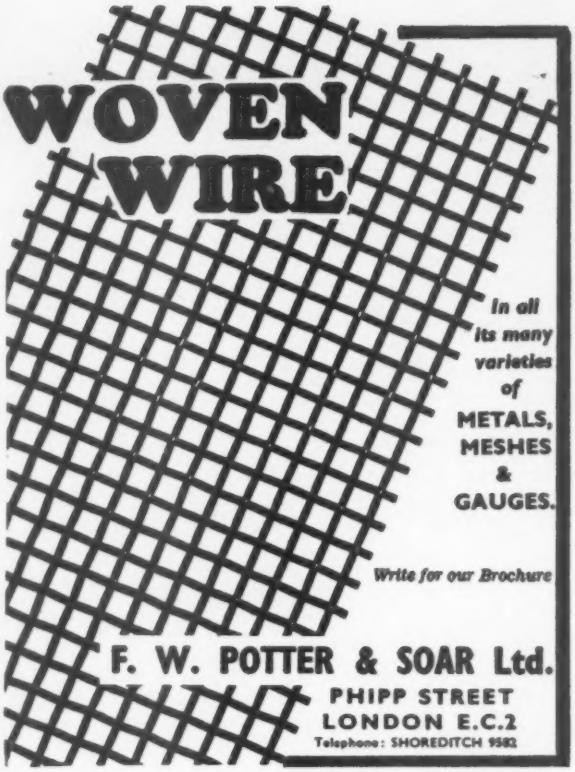

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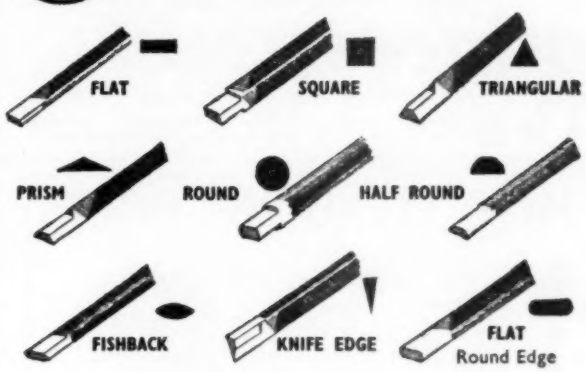

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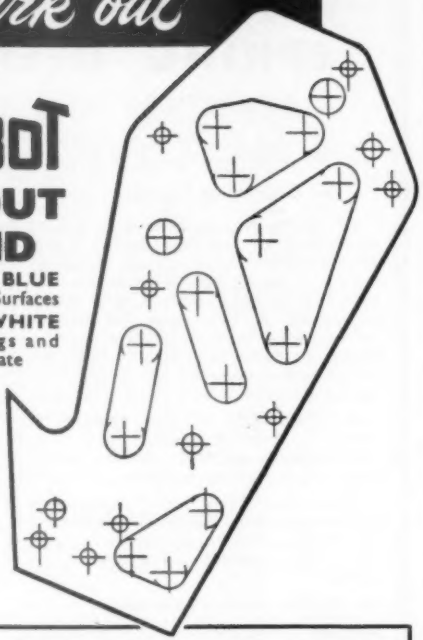

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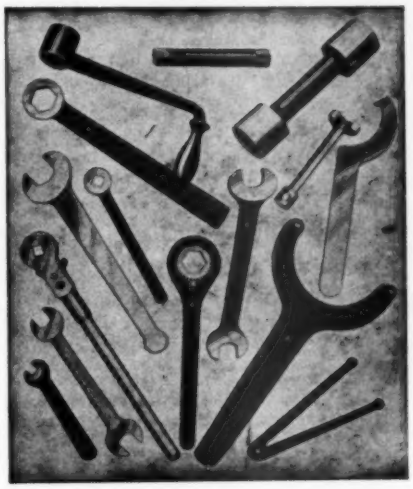

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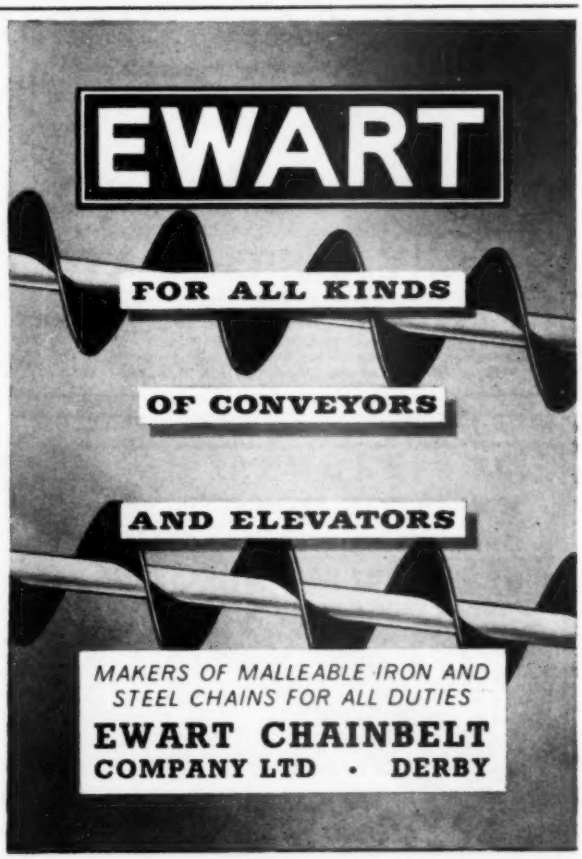

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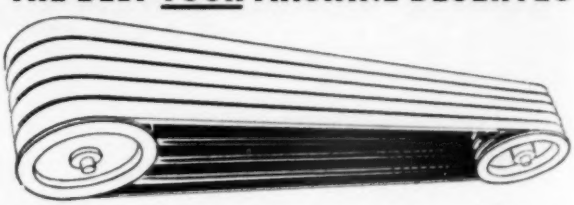

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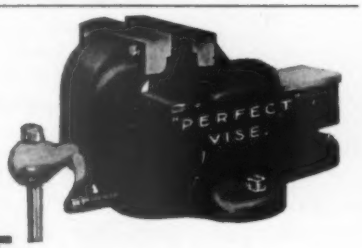

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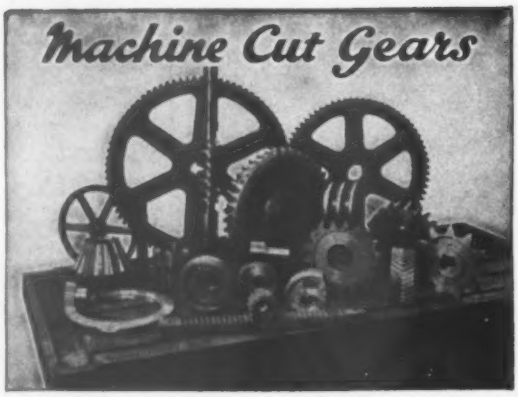

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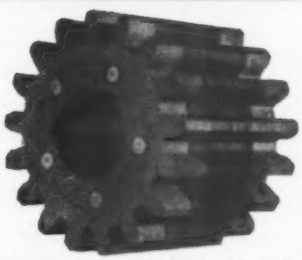

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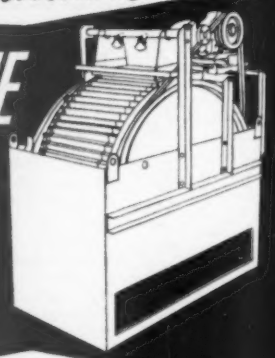

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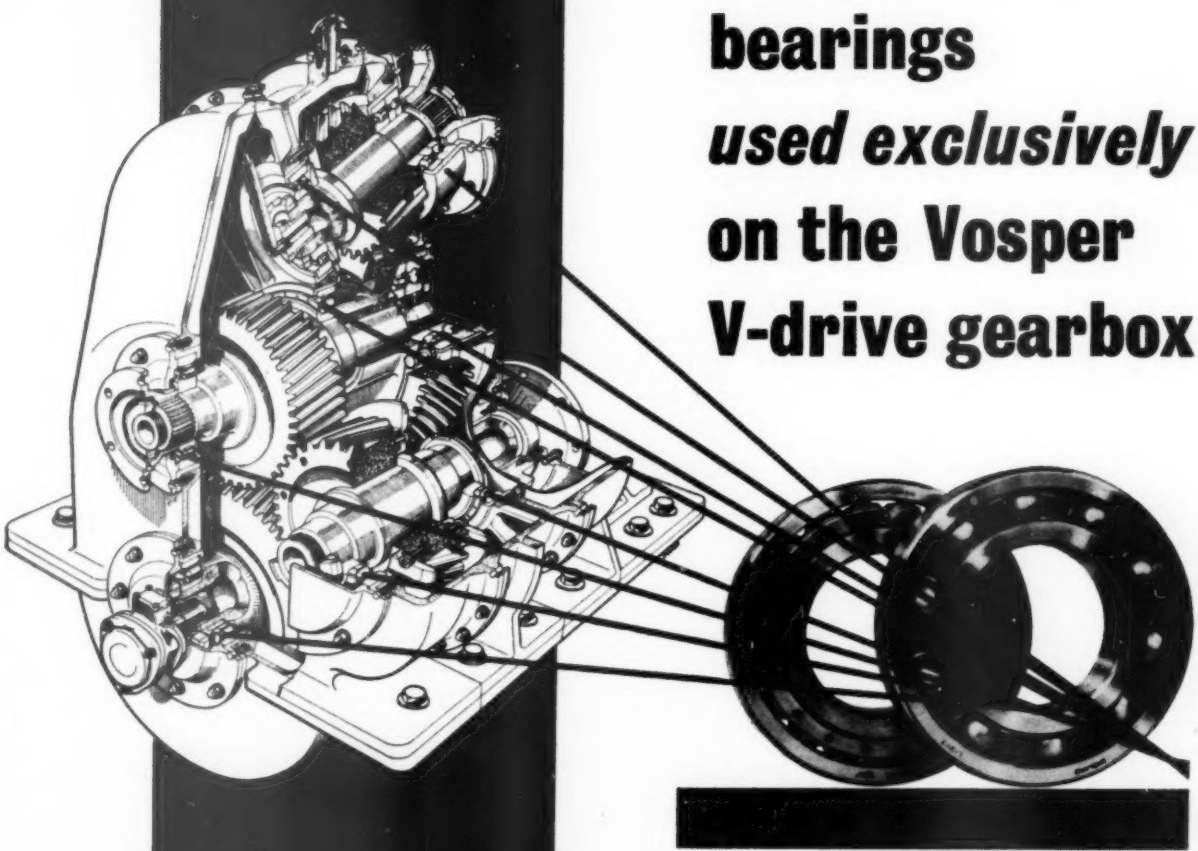

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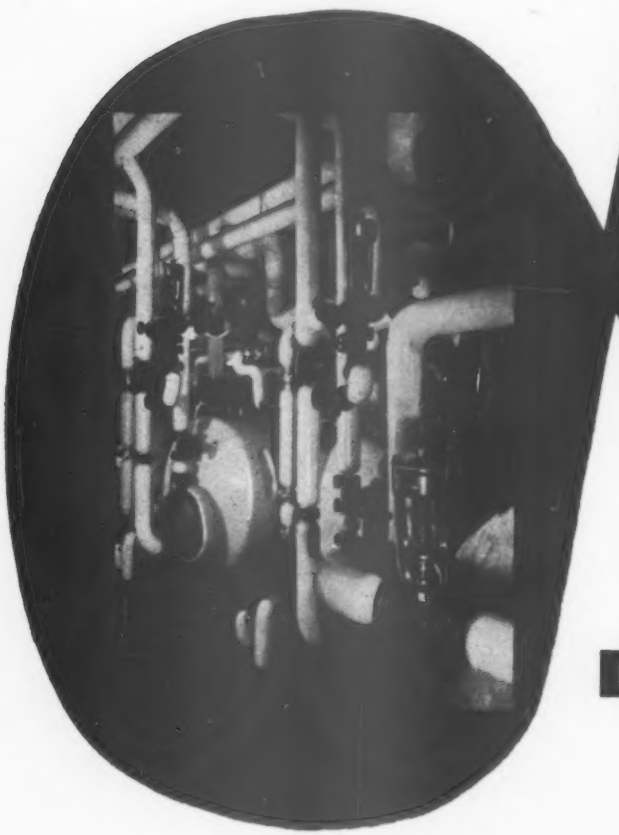

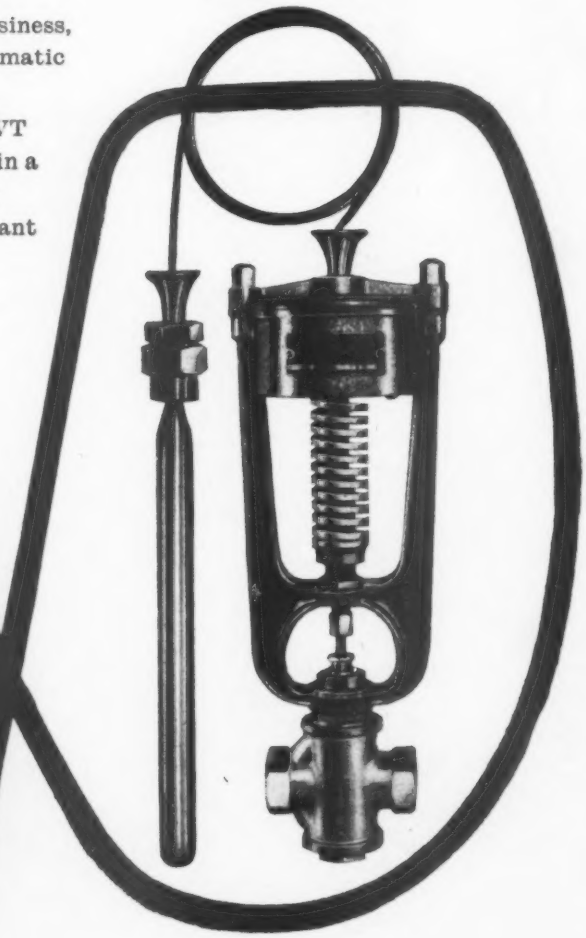

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